FEDERAL AVIATION ADMINISTRATION (FAA)

Four-Dimensional Weather Data Cube

SINGLE AUTHORITATIVE SOURCE (SAS)

Final Performance Requirements (fPR)

Version 1.0

September 30, 2009

COORDINATION VERSION

Four-Dimensional Weather Data Cube
SINGLE AUTHORITATIVE SOURCE (SAS)
Final Performance Requirements (fPR)

Executive Summary

Introduction

The Federal Aviation Administration (FAA) has developed the preliminary requirements for the Next Generation Air Transportation System (NextGen) portfolio of weather systems, including NextGen Network Enabled Weather (NNEW) and the NextGen Weather Processor (NWP). Safe and efficient NextGen operations will be dependent on enhanced weather capabilities based on three major tenets:[1]

- A common picture of the weather for all aviation transportation decision-makers and aviation system users
- Weather integrated directly into sophisticated decision support capabilities to assist decision-makers
- Use of "Internet-like" information dissemination to realize flexible and cost-efficient access to all necessary weather information

In NextGen, weather information is designed to be integrated into automation capabilities to support human decision-making processes. Through NNEW, the "common weather picture" will be enabled by development of the Four-Dimensional Weather Data Cube (4-D Wx Cube) and the associated 4-D Weather Single Authoritative Source (4-D Wx SAS) capabilities. These NextGen capabilities will evolve through 2025.

Purpose

This document provides a subset of the 4-D Wx SAS final Performance Requirements (fPR) (e.g., 'observe' and 'forecast' for super-density airports). These performance requirements will be used to support the NNEW Business Case as part of the FAA Acquisition Management System process. NNEW is comprised of the 4-D Wx Cube, the 4-D Wx SAS, and the network enabled access to this weather information by building on infrastructure provided by the System Wide Information Management (SWIM) program.

The 4-D Wx SAS is a multi-Agency initiative under the leadership of the Joint Planning and Development Office (JPDO). This subset of FAA 4-D Wx SAS performance requirements will, in part, form the basis for determining which JPDO concepts and FAA Investment Packages presented to the Joint Resources Council are viable and will satisfy all NextGen-NAS aviation weather users' requirements.

Approach

The FAA convened a multi-disciplinary NextGen Weather Performance Requirement Team (NWPRT) to develop the JPDO NextGen functional requirements into subsets of 4-D Wx Cube and 4-D Wx SAS performance requirements. Participants on the NWPRT included FAA representatives from the Air Traffic Organization (Terminal, En Route, System Operations, Technical Operations, and NextGen and Operations Planning), five general aviation (GA) pilots with private, commercial, instrument and multi-engine ratings, three air traffic control specialists with en route, terminal and flight service experience, as

[1] JPDO Next Generation Air Transportation System (NextGen) Concept of Operations (ConOps), V2.0, 13 June 2007, page ES-1

COORDINATION VERSION

well as two National Weather Service meteorologists.

The NWPRT developed the FAA's NextGen weather performance requirements based on the NextGen concepts including Super Density Operations (SDO) and Trajectory Based Operations (TBO) and sorted into the air traffic domains. The JPDO weather functional requirements that were published in January 2008 were used as the baseline; however, some modifications were made in this document (e.g., super density terminal resolution changed from 1 km to 0.5 km). The operational needs in the NextGen Enterprise Architecture (EA) and the quantified service shortfall analysis were also considered.

The resulting end-state 4-D Wx SAS performance requirements include both observed/current and forecast weather parameters. The NWPRT developed approximately 12,000 total requirements; about, 2500 functional probabilistic forecast statements and 9500 current/forecast performance requirements across terminal, en route, global and space domains based on NextGen concepts. This set of weather performance requirements will be updated as JPDO and FAA Concepts of Operations are updated or developed. These FAA weather functional and performance requirements are the first major subset of detailed NextGen requirements to be developed by any JPDO agency.

Validation

These 4-D Wx SAS functional/performance requirements are being distributed for review and validation by the JPDO agencies, as well as the meteorological communities and industry representatives. During the validation process, the operational users will determine if the 4-D Wx SAS performance requirements are a correct translation of their current and future operational needs in concert with the NextGen ConOps v2.0; while the weather community will evaluate them for meteorological reasonableness. Even if a performance requirement cannot be met in the near- or mid-term, that does not mean it is not a valid performance requirement necessary to meet a NextGen 2025 operational need. After the validation effort is completed, the FAA will use modelling and simulation with decision-maker participation to produce a final set of NextGen weather requirements.

Any requirement that can not be met due to lack of existing meteorological knowledge or technology will be allocated to Research and Development (R&D) rather than the weather roadmap. By providing performance requirements to the R&D community, new products will not be forwarded to any operational evaluation board until the requirement has been met or the operational community has determined that a less capable product can provide sufficient benefit for immediate implementation.

4-D Wx SAS Performance Requirements

Background

Although today's NAS is the safest in the world, it is under significant stress. With aircraft operations expected to grow significantly through 2025, there are well-founded concerns that the current air transportation system will not be able to accommodate even moderate growth. Super-density airports in major metropolitan settings cannot cost effectively expand by just by building more runways to meet peak demand. Without major modernization, legacy air traffic control systems will be unable to process and provide adequate flight information in real–time to support growth in the NextGen era. Also, current processes and procedures do not provide the flexibility needed to meet the growing demand for new super-density operations hubs and the shift to smaller aircraft that require more flight operations to move equal numbers of passengers. To meet the need for increased capacity and efficiency while maintaining safety at existing airports and spaceports, new technologies and processes must be implemented to accommodate higher volumes of air traffic operations safely in a cost efficient and environmentally sound manner.

Today, universal access to the best available weather information by NAS decision-makers may be incomplete, inconsistent or slowed in translation between non-standard data formats. For example, Air Traffic Control Tower (ATCT) operators at busy commercial airports may be well equipped with a suite of convective weather tools that electronically "see" gust fronts move through the local terminal airspace.

COORDINATION VERSION

However, controllers at nearby secondary / reliever terminals lack access to this same, best available weather data (for their own airspace) being unable to justify the cost of the system and/or equipment upgrades due to low service volumes.

NAS weather information dissemination must be improved from the current complex and costly systems that include point-to-point connections, and legacy information sources, weather processors and aviation user displays. While point-to-point connectivity is necessary for ensuring critical NAS data availability today, it will not always be necessary in the NextGen era given on-demand access. Also, some weather data today may be in proprietary formats that are not easily shared among non-collocated users. For example, flight-planning software integrates forecasts of textual winds and temperatures with an aircraft route and altitude, but the software is unable to either read or determine the impact of radar precipitation echoes on that same route and altitude.

A key component to achieving NextGen capabilities is the integration of weather information into automation or Decision Support Tools (DST) that combine weather with non-weather information (e.g., flight, operations, aircraft, surveillance, and aeronautical data). However, shortfalls exist today and decision-makers are frequently required to interpret and de-conflict weather information from multiple sources to determine their interpretation of the weather situation and its impacts. This slows collaborative decision-making and results in inefficient use of available airspace.

NextGen improvements will also result from incorporating weather uncertainties into user DSTs. When weather threatens to constrain aviation operations, incorporating weather information and its uncertainties into aviation operations is crucial to quantifying user risks, where risk is based on the user operational thresholds. Risks include many factors such as, safety, comfort and convenience of flight, user business objectives, and traffic flow management (TFM) objectives.

Further, real efficiencies can be realized in collaborative decision making if pilots, airline dispatchers and traffic flow managers have the same weather information as FAA air traffic management specialists. This would enable everyone to be “in-sync” on the timing of FAA, airline or pilot actions. All decision makers could well anticipate the timing and direction of NAS operational modifications in response to specific current and forecast weather impacts.

The NNEW capabilities are targeted to eliminate or minimize the current shortfalls by providing all users with network enabled access to current and forecast weather information from [virtual] global aviation weather data sets managed within the 4-D Wx Cube. The virtual 4-D Wx Cube provides access to all the weather information relevant to supporting aviation operations. The 4-D Wx SAS is a subset of the 4-D Wx Cube that represents the “common weather picture”; it provides access to gridded weather information that is consistent in time, space, and among weather elements.

4-D Wx Cube and 4-D WX Descriptions

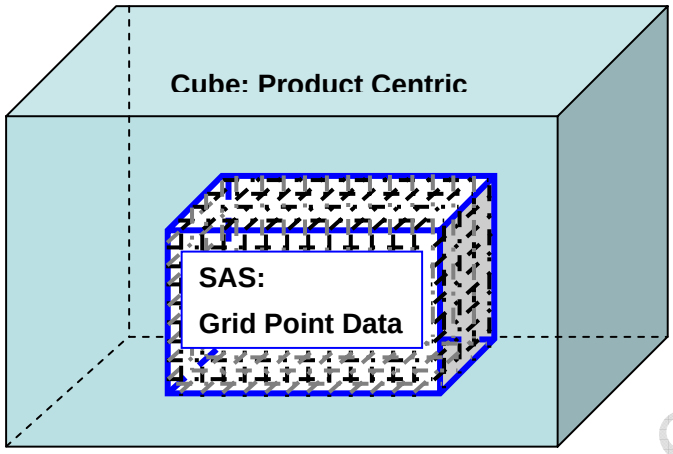
The weather data in the 4-D Wx Cube, as well as the 4-D Wx SAS, does not need to be located in a single server; but it must be network accessible (i.e., virtual). This network-enabled capability makes the physical location of information irrelevant; so long as the data or information can be found and retrieved quickly and reliably when needed. The response times for 4-D Wx Cube information requests must meet the user-specified time requirements regardless of location. Figure 1 depicts a simple conceptual relationship of the 4-D Wx Cube and the 4-D Wx SAS.

The Cube

The 4D Wx Cube represents access to all weather information used to support aviation operations, either directly or indirectly. The Cube weather information is product or data production centric. Through network enabled access, you may retrieve specific products (e.g., aviation routine weather reports (METARs) and terminal aerodrome forecasts (TAFs), as well as analyses (e.g. IFR conditions) and forecast model data (e.g., Rapid Update Cycle (RUC)).

COORDINATION VERSION

Figure 1: 4-D Wx Cube – SAS Functional Relationship



Since the 4-D Wx Cube encompasses all relevant aviation weather information from multiple sources, it will also provide information that occasionally conflicts and will have variable performance attributes, including accuracy, availability, statistical reliability, consistency, update rates, and resolution in time and space. Therefore, a means is needed to de-conflict and fuse 4-D Wx Cube information into a "common weather picture" on which all stakeholders can rely.[2] An authorized "common weather picture" is needed to facilitate decision-making by the diverse set of stakeholders and to coordinate air traffic management decisions using a variety of applications and DSTs. This "common weather picture" is the 4-D Wx SAS.

The 4-D Wx SAS

The 4-D Wx SAS is a subset of the 4-D Wx Cube and is data centric. Single values for each of the current, analyses and forecast conditions for aviation-related weather parameters (or phenomena) are available for every grid point to include increment times. For example, the Cube will provide access to forecasts from multiple forecast models; and some forecast model techniques may show better prediction 'skill' than other models in certain weather situations (e.g., pop-up thunderstorms). The 4-D Wx SAS will provide access to the resulting "consensus" forecast, the "common weather picture". In addition, the spatial and temporal requirements for the weather information at each grid point will vary based on requirements as specified by the civil Air Navigation Service Provider (ANSP) [FAA] for NextGen ATM decision-makers[3] For example, forecasts of convective weather will be updated more often than forecasts for space weather.

The 4-D Wx SAS also represents the official source of weather information used by the FAA in supporting Air Traffic Management (ATM) decisions. The 4-D Wx SAS has the following characteristics:

- Includes current observations and analyses (or interpolations) of current conditions, and predictions of future weather conditions;
- Includes probabilistic forecasts to support risk assessments and decision making;
- Will be available to all ATM decision-makers as a network-enabled part of the Cube[4].

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[2] JPDO NextGen ConOps v2.0, Section 5.3, Weather Information Services, p. 5-4.

[3] NextGen Weather Executive Panel briefing on SAS, approved July 17, 2009.

[4] ICAO ATM Concept of Operations, (ConOps) Appendix A, 2005 defines ATM decision-makers to include airlines, pilots, dispatchers, flow and capacity management, and en-route, terminal, and airport air traffic control.

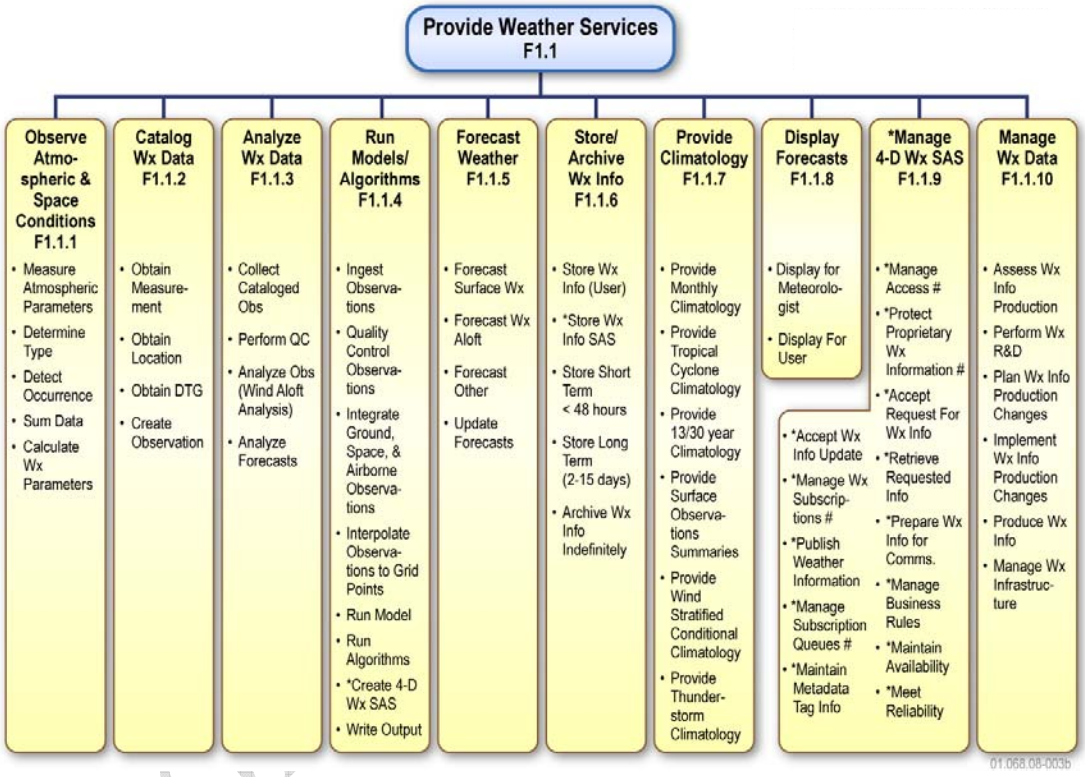
COORDINATION VERSION

DSTs will access and integrate 4-D Wx SAS weather information with non-weather information to help determine operational impacts and associated risks based on the user-established business rules and specific aircraft operating parameters. User DSTs enable enhanced risk management and will help mitigate weather impacts to NAS operations. For example, the Traffic Management Advisor (TMA) is a user DST that will integrate convection, as well as wind information from the 4-D Wx SAS to enable improved merging and sequencing information.

Scope

The initial functional requirements for all JPDO users of the 4-D Wx Cube and the 4-D Wx SAS were developed and published through the JPDO. Ten functional areas were identified in Providing Weather Services in supporting NextGen concepts as shown in Figure 2. This document only addresses the SAS functional and related performance requirements for Observe Atmospheric and Space Conditions (F 1.1.1) and Forecast Weather (F 1.1.5).

Figure 2: NextGen Weather Functions



Performance Requirements Development Process

The multi-disciplinary FAA/NWS NextGen Weather Performance Requirements Team (NWPRT) used the JPDO-sponsored functional analysis of weather requirements as the initial baseline to develop the NextGen weather performance requirements for the SAS. The functional analysis was an essential first step in developing the functional and performance requirements to meet JPDO agencies needs to plan and implement NextGen within the FAA. The functional analysis, which identified those activities that must be performed to meet stakeholder needs, was an essential tool in determining a baseline set of functional requirements that will satisfy those needs.

Before developing the SAS weather performance requirements, the NWPRT reviewed the spatial and temporal resolutions for the surface and aloft within each air traffic domain (i.e., super-density terminals, en route and global). Appropriate performance/accuracy values and tolerances were determined for each functional requirement by airspace domain. During that review process, it became obvious that there were

many common functional/performance criteria that applied equally to the 4-D Wx SAS information across any given air traffic domain. Ordered Tables N-1 were then created that include groups of common SAS Observation Performance Requirements and Tables N-2 that include the common SAS Forecast Performance Criteria (see Appendix C). Since the JPDO functional weather requirements did not include the probability forecast requirements, the NWPRT also developed those functional requirements. During the performance review process, some new functions were also added while others were deleted. The initial JPDO functional requirements were then re-baselined and NAS level performance requirements were developed for all the SAS functional requirements except for the probabilistic forecast performance requirements. The FAA anticipates that the SAS probabilistic forecast performance requirements will be completed in 2010.

SAS Probabilistic Forecasts

Many of the efficiency and capacity improvements of NextGen (e.g., Trajectory Based Operations (TBO), Capacity Management (CM), and Flow Contingency Management (FCM)) will rely on managing and coordinating the NAS impacts of weather uncertainties. The introduction and use of SAS probabilistic forecasts will quantify the uncertainty and risk in using operationally significant weather information and result in fewer lost opportunities. Probabilistic information will be used to make proactive Air Traffic Management (ATM) decisions, rather than reactive decisions. Probabilities will be provided for all SAS forecasts for all time periods ranging from the next few minutes for tactical decisions out to long-term strategic decisions looking ahead several weeks.

The use of 4-D Wx SAS probability forecasts will require policy changes on the application or use of aviation weather information. The current policies and user DSTs are primarily based on using the existing "deterministic" forecasts. User probabilistic risk tolerances will need to be established by decision-makers for use in their DSTs. Each user will determine their own tolerances in response to the forecast probabilities to establish their management of risk.

Describing the content, as well as the functional and performance requirements of probabilistic weather information, is a challenge due to the lack of experience with using this type of information in decision-making Implementation of the final functional and performance requirements will rely on consistent interaction between researchers and the NextGen users of probabilistic weather information, as well as the developers of DSTs.

Weather Enterprise Decision Support Service (WEDSS) Functions

The NWPRT determined that additional functions were necessary to provide the information required by users that will not be directly measured or forecast. Some of the weather information the user requires can not be directly extracted from the 4-D Wx SAS grid point data; information such as density altitude, maximum daily temperature over the last 24 hours, or altimeter settings. For example, the requirement for specifying when a weather phenomenon impacts operations (e.g., time when precipitation (rain or snow) will begin or end at an airport) depends on the users' operational needs. The most appropriate and efficient method for supporting such a large range of operational requirements is to establish a weather enterprise service that can examine the 4-D Wx SAS grid values and provide tailored information to the user. To reduce costs and data latency, some weather information will be calculated centrally for immediate broadcast of identical information (i.e., same formula used). These new functions are listed at the end of Appendix B and resulted in a new functional category, Weather Enterprise Decision Support Services (WEDSS), as a part of providing NextGen weather support.

To support such NextGen weather requirements, the action verb "forecast" of some of the functional and performance requirements became "determine" or "calculate" and a Weather Enterprise Service-Decision Support Tool (WES-DST) beyond the Cube and SAS will be needed to perform that function. In general, the "determine" functions are those that were deemed not needed at every point in the NAS, needed only occasionally or needed for specific applications. Users or a function within the weather enterprise would be required to extract the needed information from the 4-D Wx SAS via the WES-DST. Examples of

COORDINATION VERSION

functions which are to be "determined" include: vertical extent, horizontal extent, layer thickness, beginning time, ending time, and duration of weather elements. These performance requirements will be provided after the comments on the observed and forecast requirements have been received.

4-D Wx SAS Tables – Functional and Performance Requirements

The temporal and spatial resolution of weather information in the 4-D Wx SAS varies according to geographic region and airspace. For airspace in which aircraft are in close proximity and operations are highly active, temporal and spatial resolution will be finer. For less active air traffic operations or for low volumes of traffic (e.g., oceanic), temporal and spatial resolution will be coarser. For example, gridded weather forecasts in the vicinity of super-density terminals will have a finer horizontal resolution than for other airspace (e.g., 0.5 km in terminal vs. 4 km in en route vs. 10 km for oceanic and global). As a result, the resolution and update rate of weather information are more closely aligned to users' needs; and are provided to minimize service gaps.

Appendix C provides all the weather parameter attributes and temporal and spatial resolution, as well as performance requirements values for the 4-D Wx SAS [except for probabilistic forecasts]. The values were developed and are presented in functionally organized tables. The SAS performance requirements when iterated over all domains and common weather attributes resulted in over 12,000+ weather requirements statements (NAS-level to program level) based on users' NextGen weather needs, circa 2025. At this early point in the AMS process, the FAA weather functional and performance requirements have not been allocated to any agency or system. The NWPRT has made an initial draft allocation of those requirements to either the 4-D Wx SAS, the 4-D Wx Cube, users' DST, or the Weather Enterprise Decision Support Services. After these SAS requirements are validated via modelling and simulation, they will be allocated as service gaps to legacy and new NAS systems and decomposed into specifications.

Conclusion/Summary

These FAA, year 2025, SAS weather performance requirements are established to satisfy all NextGen NAS aviation weather user's needs. These requirements include both observed and forecast weather parameters and will be validated by all NextGen decision-makers in 2010. Once comment resolution has been completed, the FAA will use modelling and simulation with participation by a selected set of NAS decision-makers as a final validation of these NextGen NNEW weather performance requirements. Then after these NNEW requirements are validated, the FAA will allocate the functional requirements and associated performance requirements to specific systems and R&D activities on the NAS Enterprise Architecture Weather Roadmap. Additionally, during FY10, the NWPRT will develop the NextGen probabilistic forecast performance requirements, performance requirements for functions other than observe & forecast, and will address the time phasing of Midterm (circa 2018) weather performance requirements.

The following appendices are included:

Appendix A – Airspace Categories for 2025 NextGen Weather Support.

Provides descriptions of the airspace environments aligned to the NextGen ConOps that were used to determine the NextGen Weather functional and performance requirements.

Appendix B – JPDO 4-D Weather Functional Requirements for NextGen ATM.

COORDINATION VERSION

Provides an updated extract from the January 2008 JPDO 4-D Weather Functional Requirements document. Includes hierarchical diagrams that illustrate the relationship of the Weather Services to the NextGen Enterprise Architecture V2. Also includes the detailed functional requirements for the Observe, Forecast and the new Weather Enterprise Decision Support Services functions.

Appendix C – SAS Functional and Performance Criteria Tables.

Provides summary tables that describe the spatial and temporal resolutions for the surface and aloft within each air traffic domain described in Appendix A. Also provides the associated performance/accuracy values and tolerances.

Appendix D – Performance Requirements for Observe Atmospheric and Space Conditions for Super Density Terminals Airspace.

Provides detailed listings of the performance requirements for the SAS Observe Atmospheric and Space Conditions functional requirements

Appendix E – Performance Requirements for Forecast Weather for Super Density Terminals Airspace. Provides detailed listings of the performance requirements for the SAS Forecast Weather functional requirements

Appendix F - NextGen SAS Functional Probability Requirements.

Provides a detailed listing of the SAS functional requirements for probability forecasts.

Review Examples:

The following examples of 4-D Wx SAS functional and performance requirements are provided to assist in understanding the association of the Appendices B through F.

<u>Functional Requirements Statements:</u> The following are examples of SAS functional requirements statements that are listed in Appendix B. The spatial and temporal criteria that are used to construct these statements are provided in the Summary Tables in Appendix C. The specific table references are noted in [ ] after each functional requirement.

The 4-D Wx SAS shall provide:

- Forecasts for super-density terminal airspace with 0.5 km horizontal resolution [Table N-2c].
- Non-convective forecasts for super-density Terminals at
  - 15-minute increments for time 0-4 hours [Table N-2a]
  - 1-hour increments from 4 to 60 hours [Table N-2a]
  - 3-hour increments from 60 hours to 14 days [Table N-2a]
- Convective forecasts for super-density terminal airspace in 10-minute increments out to 2 hours [Table N-2a]
- Non-convective forecasts En route airspace at 4-km horizontal resolution [Table N-2c]
- Convective forecasts for En route airspace at 1-km horizontal resolution [Table N-2c]

COORDINATION VERSION

Performance Requirements Statements: The following are examples of SAS Weather Forecast performance requirements statements that are listed in Appendix E and correspond to the SAS functional requirements listed above. The accuracy values that are used to construct these statements are also provided in the Summary Tables in Appendix C.

Extracts of the Summary Tables from Appendix C are provided and an overall example plus a specific example is provided for each Table. The blocks in each table that related to the specific example are highlighted.

Forecast Horizontal (Location) Accuracy

- Overall: The NextGen Forecast horizontal accuracy shall be plus or minus values specified in Table N-2g below for each respective time period and domain.
- Specific: The NextGen Forecast horizontal accuracy shall be plus or minus 1/4 km in latitude and longitude location for 0-2 hour forecasts in the Terminal Air Traffic Domain.

Table N-2g Forecast Accuracy - Location (Lat/Long)

Forecast Valid Period	Air Traffic Domain			
	Terminal	En Route		Global
		Convective	Other Wx	
0-2hrs	1/4 km	1/2 km	2 km	5 km
2-4hrs		1 km		
4-10 hrs	1/2 km	2 km		
10-24hrs				
24-60 hrs	1 km			
60hrs-14 days	2 km	4 km	4 km	10 km

Forecast Vertical (Base/Tops) Accuracy

- Overall: The NextGen Forecast vertical accuracy shall be plus or minus values specified in Table N-2f for each respective time period, domain, and altitude stratum.
- Specific: The NextGen Forecast vertical accuracy shall be plus or minus 50 ft for all 0-2 hour forecasts for conditions between Surface to 4900 ft in the Terminal Air Traffic Domain.

COORDINATION VERSION

Table N-2f Forecast Accuracy - Bases/Tops

Forecast Valid Period	Air Traffic Domain		
	Terminal	En Route	Global
0-2 hrs			
5,000 ft - Top of NAS	250 ft	250 ft	250 ft
Surface – 4,900 ft	50 ft		
2-4 hrs			
5,000 ft - Top of NAS	250 ft	250 ft	250 ft
Surface - 4,900 ft	50 ft		
4-10 hrs			
5,000 ft - Top of NAS	500 ft	500 ft	500 ft
Surface - 4,900 ft	100 ft		
10-24 hrs			
5,000 ft - Top of NAS	500 ft	500 ft	500 ft
Surface - 4,900 ft	100 ft		
24-60 hrs			
5,000 ft - Top of NAS	1,000 ft	1,000 ft	1,000 ft
Surface - 4,900 ft	150 ft		

COORDINATION VERSION

Appendix A: Airspace Categories for 2025 NextGen Weather Support

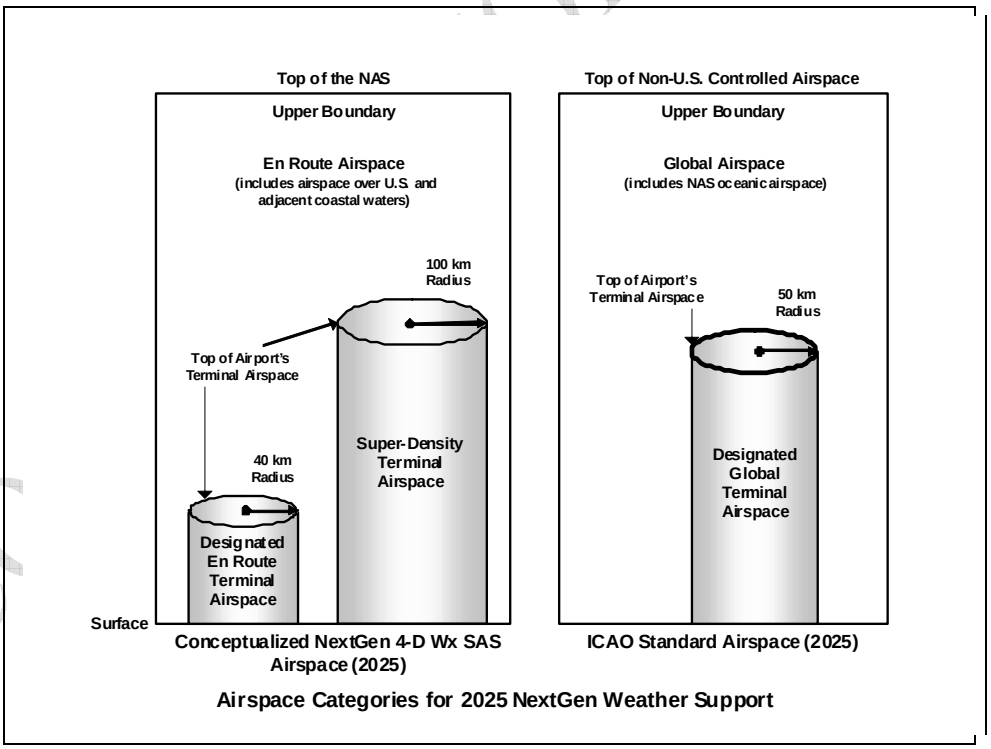
1. **Super-Density Terminal Airspace** – a volume of airspace centered over super-density airports with a base at the surface, a radius of 100 km, and an upper boundary at the top of the airport's terminal airspace. This category includes domestic airports that each account for at least one percent of total U.S. passenger enplanements.

2. **Designated En Route Terminal Airspace** – a volume of airspace centered over selected en route airports with a base at the surface, a radius of 40 km, and an upper boundary at the top of each airport's terminal airspace. This category may include medium and small hub airports not included in the area covered by Super-Density Terminal Airspace.

3. **En Route Airspace** – all domestic airspace outside Super-Density Terminal Airspace and Designated En Route Terminal Airspace, with a base at the surface and an upper boundary at the top of the NAS. This category includes all domestic airports not included in the area covered by Super-Density Terminal Airspace and Designated En Route Terminal Airspace.

4. **Designated Global Terminal Airspace** – a volume of airspace centered over selected global airports with a base at the surface, a radius of 50 km, and an upper boundary at the top of each airport's terminal airspace.

5. **Global Airspace** – all non-domestic airspace outside Designated Global Terminal Airspace with a base at the surface and an upper boundary at the top of controlled airspace



Airspace Categories for 2025 NextGen Weather Support

Appendix B: JPDO 4-D Weather Functional Requirements for NextGen ATM

This Appendix is an updated extract from the JPDO 4-D Weather Functional Requirements published in January 2008. It includes several diagrams (Figures B-1, B-2, and B-3, which relate pictorially the functional hierarchy of how low level Weather Services (or functions) of Observe Weather and Forecast Weather are tied to the higher level Enterprise Services (or functions). Lastly, a listing of the SAS functional requirements is provided using a hierarchical numbering scheme to depict a "parent-child" relationship of the subfunction 'child' under its function 'parent'. Detailed functional requirement are provided for the Observe (F1.1.1) and Forecast (F1.1.5) functions along with the new Weather Enterprise Decision Support Services function (F1.1.11) that is not yet included in the Figure B-1 below.

> Note: The functional requirements statements include strike-through items that were determined by the NWPRT to be either not needed or were realigned to other functional requirements statements.

Figure B-1. Functional Hierarchy for Enterprise Services

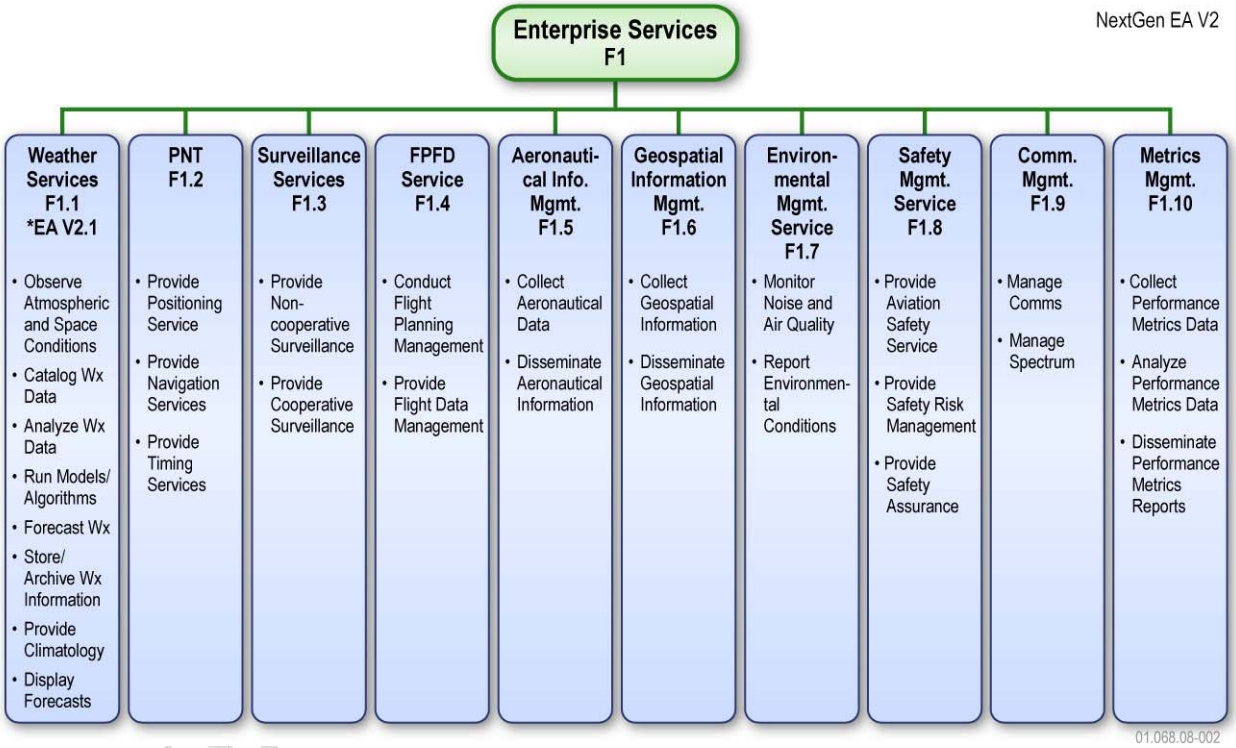


Figure B-2. Functional Hierarchy for Observe Atmospheric and Space Conditions

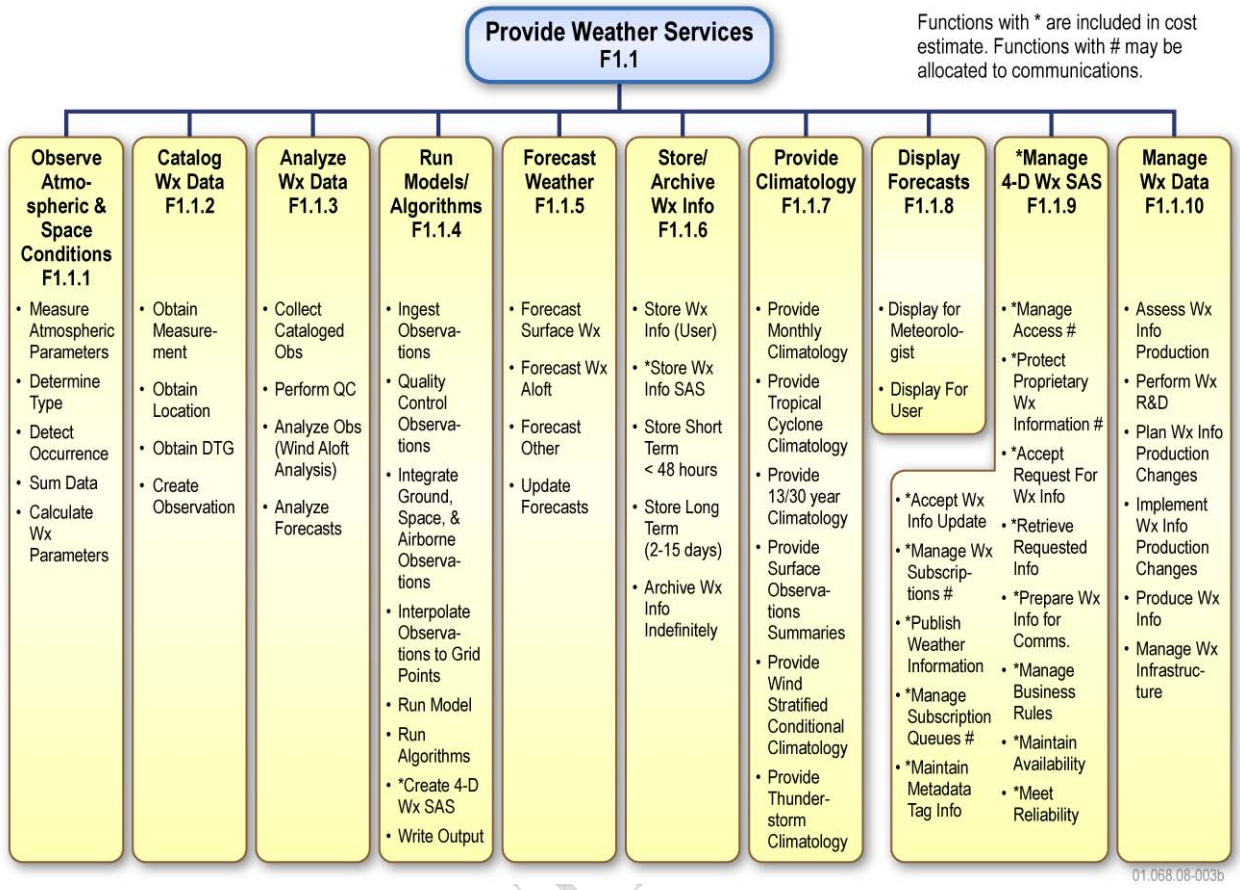
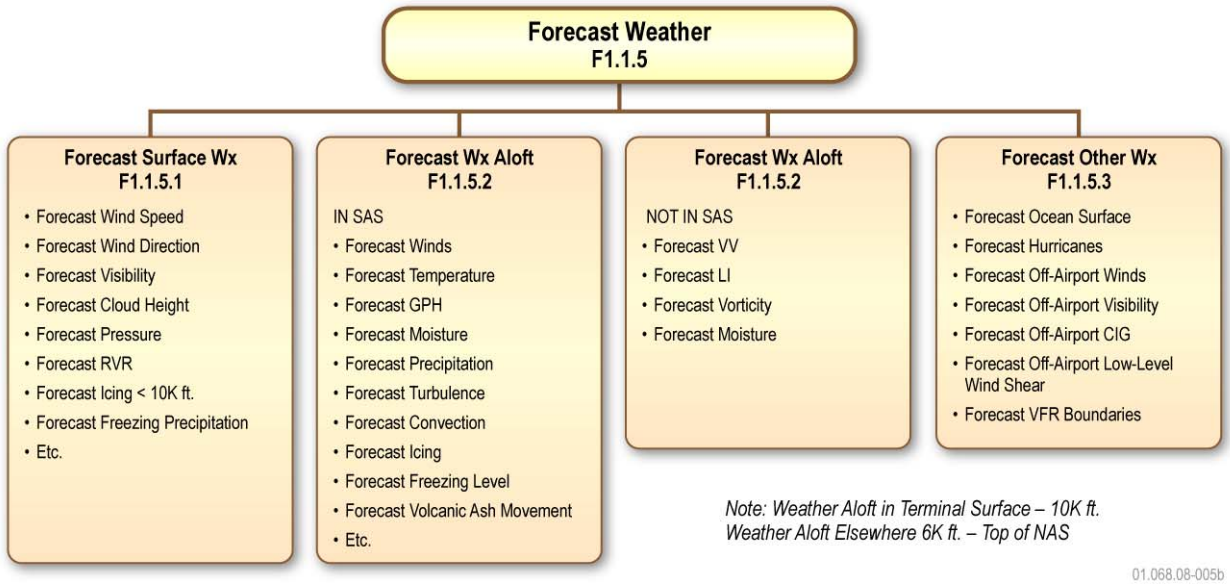


Figure B-3. Functional Hierarchy for Forecast Weather



The functional decomposition starts at the highest level, that of Enterprise Services F1, as shown in Figure B-1. From the left side of Figure B-1, under Weather Services F1.1, one can see the origin of the Observe and Forecast weather functions. Figures B-2 and B-3 provide additional information about the

sub-functions under Observe Atmospheric and Space Conditions and Forecast Weather functions, respectively. In addition, as Enterprise Services (or functions) they support various services under Enterprise Services that require weather data/information, including Surveillance Services and Flight Planning Services.

The symbols in the following list indicate the traceability of the Observe and Forecast functions to the Next Generation Air Transportation System Concept of Operations (NextGen ConOps) v2.0 subfunctions:

Provide weather information to support:	Symbol to use for traceability:
Air Traffic Operations	#
Traffic Management (or Capacity) Operations	*
Flight Community (Operators)	^
Terminal Airspace Configuration	~
Ground Operations	%

Items residing within the 4-D Wx Cube, but not in the 4-D Wx SAS, have a "+" symbol immediately after the function. Note that some of the Observe and Forecast functions listed may not exist by the time NextGen is implemented, or may have changed significantly to meet the 4-D Wx SAS requirements per the list below. For example, at present, ceiling and visibility are essential to air traffic management (ATM), but with significant research and development (R&D), a capability may be developed (e.g., "synthetic vision") that allows these functions to be removed. As R&D progresses and as the NextGen weather needs become more detailed, we anticipate (and encourage) additional modification to the functional hierarchy. Although sometimes lengthy team discussions were held concerning the functions described below, it is important to note, when reviewing the list below, that these discussion often led to the realization that there was simply not enough information available for a more exact definition of the function.

F.1 Enterprise Services

F1.1 Provide Weather Services—Level at which 4-D Wx SAS resides (Section 4)

F1.1.1 Observe[5] Atmospheric and Space Conditions

Note: For brevity, the leading "F1.1" *in the numbering scheme is eliminated hereafter. For example,* "F1.1.1 Observe Atmosphere and Space Conditions" *becomes* "**l Observe Atmosphere and Space Conditions" and 'F1.1.5 Forecast Weather' becomes '5 Forecast Weather'**:

1 Observe Atmosphere and Space Conditions

1.1 Observe Atmospheric Conditions+

- **Observe Present Surface Weather** ^ # * ~ %

1.1.11 **Observe Surface Liquid Precipitation +** ^ # * ~

1.1.1.1.1 Determine Liquid Precipitation Type ^ #

[5] Observe = To evaluate or measure, by human or automated means, one or more meteorological elements (e.g., temperature, wind speed/direction, visibility, precipitation) that describe the state of the atmosphere either at Earth's surface or aloft.

COORDINATION VERSION

455	1.1.1.1.1.1	**Determine Location of Drizzle**	^ #	
456	**1.1.1.1.1.1.1**	Determine[6] Horizontal Extent of Drizzle	^ # *	
457	**1.1.1.1.1.1.2**	Determine Vertical Extent of Drizzle	^ #	
458	1.1.1.1.1.2	**Determine Location of Rain**	^ #	
459	**1.1.1.1.1.2.1**	Determine Horizontal Extent of Rain	^ # *	
460	1.1.1.1.1.2.2	Determine Vertical Extent of Rain		
461	**1.1.1.1.1.3**	**Determine Location of Rain Shower(s)**	^ #	
462	1.1.1.1.1.4	Measure[7] Accumulation of Liquid Precipitation	^ #	
463	1.1.1.1.1.5	Determine Movement Direction of Liquid Precipitation	^ #	
464	1.1.1.1.1.6	Determine Movement Speed of Liquid Precipitation	^ #	
465	1.1.1.1.1.7	Calculate Rain Fall Intensity	^ #	
466	**1.1.1.1.1.7.1**	Calculate Rain Fall Rate (inches/hour)	^ # *	
467	~~**1.1.1.1.1.7.1.1**~~	~~Determine Beginning Time of Liquid Precipitation~~	~~^ #~~	
468	~~**1.1.1.1.1.7.1.2**~~	~~Determine Ending Time of Liquid Precipitation [Up leveled]~~	~~^ #~~	
469	**1.1.1.2 Observe Surface Solid Precipitation +**			
470	1.1.1.2.1	**Determine Solid Precipitation Type**	^ #	
471	**1.1.1.2.1.1 Determine Location of Hail**		^ #	%
472	**1.1.1.2.1.1.1**	Determine Horizontal Extent of Hail	^ # *	%
473	**1.1.1.2.1.1.2**	Estimate Size of Largest Hailstone (inches)	^ #	
474	**1.1.1.2.1.1.3**	Determine Location of Hail Shower	^ #	
475	1.1.1.2.1.1.4	Determine Vertical Extent of Hail		
476	**1.1.1.2.1.2 Determine Location of Snow**		^ #	
477	**1.1.1.2.1.2.1**	Determine Horizontal Extent of Snow	^ # *	%
478	**1.1.1.2.1.2.2**	Measure Snowfall Accumulation	^ # *	%
479	**1.1.1.2.1.2.3**	—Determine Location of Snow Showers	^ # *	
480	**1.1.1.2.1.2.4**	Calculate Snowfall Rate (inches/hour)	^ # *	%
481	**1.1.1.2.1.2.4.1**	~~Determine Snowfall Beginning Time~~	^ # *	%
482	**1.1.1.2.1.2.4.2**	~~Determine Snowfall Ending Time~~ [Up leveled]	^ # *	%
483	**1.1.1.2.1.2.5**	Calculate Water Equivalent of Snowfall (inches/hour)	^ #	%
484	1.1.1.2.1.2.6	Determine Vertical Extent of Snow		
485	~~**1.1.1.2.1.2.7**~~	~~Calculate snowfall intensity~~ [Moved to WESDST]	~~^ # * %~~	
486	**1.1.1.2.1.3 Observe Ice Crystals+**		^ #	
487	1.1.1.2.1.3.1	Determine Location of Ice Crystals		
488	**1.1.1.2.1.3.2**	Determine Horizontal Extent of Ice Crystals	^ #	
489	1.1.1.2.1.3.3	Determine Vertical Extent of Ice Crystals		
490	1.1.1.2.1.3.4	~~Determine Beginning Time of Ice Crystals~~ [Up leveled]		
491	~~1.1.1.2.1.3.5~~	~~Determine Ending Time of Ice Crystals~~		
492	**1.1.1.2.1.4 Observe Ice Pellets**		^ #	

[6] Determine = To establish or ascertain definitely, as after consideration, investigation, or calculation.

[7] Measure = To ascertain the extent, dimensions, quantity, capacity, and so on, by comparison with a standard.

COORDINATION VERSION

1.1.1.2.1.4.1	Determine Location of Ice Pellets	^ #
1.1.1.2.1.4.2	Determine Horizontal Extent of Ice Pellets	^ #
1.1.1.2.1.4.3	Measure Ice Pellet Intensity	^ #
1.1.1.2.1.4.4	~~Determine Beginning Time of Ice Pellets~~ [Up leveled]	^ # *
1.1.1.2.1.4.5	~~Determine Ending Time of Ice Pellets~~	^ # *
1.1.1.2.1.5	**Determine Location of Snow Grains**	^ #
1.1.1.2.1.6	Determine Location of Blowing Snow	^ #
1.1.1.2.1.6.1	Determine Where Snow Is Blowing Over Runways[8]	^ # * ~ %
1.1.1.2.1.6.2	Determine Horizontal Extent of Blowing Snow	
1.1.1.2.1.7	Determine Location of Low Drifting Snow	^ # * ~ %
1.1.1.2.1.7.1	Determine Horizontal Extent of Low Drifting Snow	
1.1.1.2.1.8	Determine Location of Small Hail	^ #
1.1.1.2.1.8.1	Determine Horizontal Extent of Small Hail	
1.1.1.2.1.9	**Determine Location of Snow Pellets**	^ #
1.1.1.2.1.9.1	~~Determine Beginning Time of Snow Pellets~~	^ #
1.1.1.2.1.9.2	~~Determine Ending Time of Snow Pellets~~ [Up leveled]	^ #
1.1.1.2.1.9.3	Determine Horizontal Extent of Snow Pellets	
1.1.1.3	**Observe Surface Freezing Precipitation +**	^ # * ~
1.1.1.3.1	**Determine Location of Freezing Rain**	^ # * ~ %
1.	Determine Horizontal Extent of Freezing Rain	^ # * ~ %
2.	**Determine Location of Freezing Drizzle**	^ # * ~ %
1.	Determine Horizontal Extent of Freezing Drizzle	^ # * ~ %
3.	**Determine Existence of Surface Icing Conditions**	^ # * ~ %
1.1.1.3.3.1	Determine Time When Surface Icing Accretion Began	^ # * ~ %
1.1.1.3.3.2	Measure Intensity of Freezing Precipitation	^ # ~ %
~~**1.1.1.3.3.3**~~	~~Determine Surface Icing Accretion Rate~~ [WESDST]	~~^ # * ~ %~~
1.1.1.3.3.3.1	~~Determine Beginning Time of Freezing Precipitation~~	^ # * ~ %
1.1.1.3.3.3.2	~~Determine Ending Time of Freezing Precipitation~~ [Up leveled]	^ # * ~ %
1.1.1.3.4	Determine Beginning Time of Precipitation	
1.1.1.3.5	Determine Ending Time of Precipitation	
1.1.1.3.6	Calculate the total amount of ice accretion	
•	**Observe Surface Obscurations to Visibility**	^ # *
1.1.1.4.1	Determine Location of Haze	^ # *
1.1.1.4.2	Determine Location of Smoke	^ # *
1.1.1.4.3	Determine Location of Mist	^ # *
1.1.1.4.4	Determine Location of Fog	^ # * ~
1.1.1.4.4.1	Determine Location of Shallow Fog	^ # *
1.1.1.4.4.2	Determine Location of Partial Fog	^ # *
1.1.1.4.4.3	Determine Location of Fog Patches	^ # *

[8] But not snowing at point of observation.

COORDINATION VERSION

532	1.1.1.4.4.4	Determine Location of Freezing Fog	^	#	*		
533	1.1.1.4.5	Determine Location of Blowing Spray	^	#			
534	1.1.1.4.6	Determine Location of Blowing Sand	^	#	*	~	%
535	1.1.1.4.6.1	Determine Location of Low Drifting Sand	^	#		~	%
536	1.1.1.4.7	Determine Location of Blowing Snow	^	#	*		
537	1.1.1.4.8	Determine Location of Widespread Dust	^	#	*		
538	1.1.1.4.9	Observe Surface Volcanic Ash	^	#	*	~	
539	1.1.1.4.9.1	Determine Horizontal Extent of Surface Volcanic Ash	^	#	*	~	%
540	**1.1.1.4.10**	Determine Horizontal Extent of Surface Obscurations					
541	1.1.1.4.11	Determine Beginning Time of Surface Obscurations					
542	1.1.1.4.12	Determine Ending Time of Surface Obscurations					
543	1.1.1.4.13						
544	**1.1.1.5**	Measure Vertical Visibility **Observe Other Surface Weather +**					
545	1.1.1.5.1	**Observe Thunderstorms**	^	#	*	~	
546	1.1.1.5.1.1	Calculate Direction of Thunderstorm Movement	^	#	*	~	
547	1.1.1.5.1.2	Calculate Speed of Thunderstorm Movement	^	#	*		
548	1.1.1.5.1.3	Determine Thunderstorm Intensity	^	#	*	~	
549	1.1.1.5.1.4	Determine Horizontal Extent of Thunderstorm	^	#	*	~	
550	1.1.1.5.1.5	Determine Vertical Extent of Thunderstorm	^	#	*		
551	1.1.1.5.1.6	Measure Thunderstorm Cell Intensity	^	#	*	~	
552	1.1.1.5.1.7	Determine Thunderstorm Cell Location	^	#	*	~	
553	1.1.1.5.1.8	Determine Thunderstorm Initiation Location	^	#	*		
554	1.1.1.5.1.9	Determine Thunderstorm Growth Location	^	#	*		
555	1.1.1.5.1.10	Determine Location of Thunderstorm Decay	^	#	*		
556	1.1.1.5.1.11	Determine Beginning Time of Thunderstorms	^	#	*		
557	1.1.1.5.1.12	Determine Ending Time of Thunderstorms	^	#	*		
558	1.1.1.5.1.13	Determine location of thunderstorms					
559	1.1.1.5.2	**Observe Mesocyclone +**					
560	1.1.1.5.2.1	Determine Location of Mesocyclone	^	#	*		
561	1.1.1.5.2.2	Measure Mesocyclone Speed of Movement	^	#	*		
562	1.1.1.5.2.3	Measure Mesocyclone Direction of Movement	^	#	*		
563	1.1.1.5.2.4	Measure Mesocyclone Intensity	^	#	*		
564	1.1.1.5.2.5	Determine Beginning Time of Mesocyclones					
565	1.1.1.5.2.6	Determine Ending Time of Mesocyclones					
566	1.1.1.5.3	**Observe Gust Fronts +**					
567	1.1.1.5.3.1	Determine Gust Front Location		#	*		
568	1.1.1.5.3.2	Measure Gust Front Movement Direction		#	*		
569	1.1.1.5.3.3	Measure Gust Front Movement Speed		#	*		
570	1.1.1.5.3.4	Determine Time of Gust Fronts					
571	1.1.1.5.4	**Observe Cloud-to-Ground Lightning +**					
572	1.1.1.5.4.1	~~Measure Frequency of Cloud-to-Ground Lightning~~	^	#	*		%

COORDINATION VERSION

573	1.1.1.5.4.2	Determine Location of Cloud-to-Ground Lighting	
574	1.1.1.5.4.3	Determine Peak Current of Cloud-to-Ground Lightning	
575	1.1.1.5.4.4	Determine Polarity of Cloud-to Ground Lightning	
576	1.1.1.5.4.5	Determine Flash Multiplicity of Cloud-to Ground Lightning	
577	1.1.1.5.4.6	Determine Beginning Time of Lightning	
578	1.1.1.5.4.7	Determine Ending Time of Lightning	
579	1.1.1.5.5	**Observe Wind Shear/Microburst +**	
580	1.1.1.5.5.1	Observe Wind Shear	
581	1.1.1.5.5.1.1	Determine Location of Low-Level Wind Shear	^ #
582	1.1.1.5.5.1.2	Determine Vertical Extent of Low-Level Wind Shear	^ #
583	1.1.1.5.5.1.3	Measure Change in Wind Speed or Direction of Low-Level Wind Shear	^ #
584	1.1.1.5.5.1.4	Measure Movement Direction of Wind Shear	^ # * ~
585	1.1.1.5.5.1.5	Measure Movement Speed of Wind Shear	^ # * ~
586	1.1.1.5.5.1.6	Determine Beginning Time of Wind Shear	^ # *
587	1.1.1.5.5.1.7	Determine Ending Time of Wind Shear	^ # *
588	1.1.1.5.5.2	**Observe Microbursts**	
589	1.1.1.5.5.2.1	Determine Location of Microbursts	^ #
590	1.1.1.5.5.2.2	Determine Vertical Extent of Microbursts	^ #
591	1.1.1.5.5.2.3	Measure Airspeed Loss/Gain of Microbursts	^ #
592	1.1.1.5.5.2.4	Measure Movement Direction of Microbursts	^ # *
593	1.1.1.5.5.2.5	Measure Movement Speed of Microbursts	^ # * ~
594	1.1.1.5.5.2.6	Determine Beginning Time of Microburst	^ # *
595	1.1.1.5.5.2.7	Determine Ending Time of Microburst	^ # *
596	1.1.1.5.6	**Observe Squalls[9] +**	^ # * ~
597	1.1.1.5.6.1	Determine Location of Squalls	^ # * ~
598	1.1.1.5.6.2	Measure Squall Wind Speed	^ # * ~
599	1.1.1.5.6.3	Measure Squall Wind Direction	^ # * ~
600	1.1.1.5.6.4	Determine Beginning Time of Squall	^ # * ~
601	1.1.1.5.6.5	Determine Ending Time of Squall	^ # * ~
602	1.1.1.5.7	**Observe Tornadic Activity +**	^ # * ~
603	1.1.1.5.7.1	**Determine Funnel Cloud Location**	^ # * ~ %
604	1.1.1.5.7.1.1	Measure Funnel Cloud Movement Direction	^ # * ~ %
605	1.1.1.5.7.1.2	Measure Funnel Cloud Movement Speed	^ # * ~
606	1.1.1.5.7.1.3	~~Measure Funnel Cloud Intensity~~	^ # * ~
607	1.1.1.5.7.1.4	Determine Funnel Cloud Beginning Time	^ # * ~
608	1.1.1.5.7.1.5	Determine Funnel Cloud Ending Time	^ # * ~
609	1.1.1.5.7.2	**Determine Tornado Location**	^ # * ~ %
610	1.1.1.5.7.2.1	Measure Tornado Movement Direction	^ # * ~ %

[9] Squall = In an observing practice in the United States, a squall would be reported only if a wind speed of 16 knots or higher were sustained for at least 2 minutes (distinguishing it from a gust, with a duration of seconds).

COORDINATION VERSION

611	1.1.1.5.7.2.2	Measure Tornado Movement Speed	^	#		~	
612	1.1.1.5.7.2.3	~~Measure Tornado Intensity (F #)~~	^	#	*	~	
613	1.1.1.5.7.2.4	Determine Tornado Cloud Base Height	^	#	*		
614	1.1.1.5.7.2.5	Determine Tornado Beginning Time	^	#	*	~	
615	1.1.1.5.7.2.6	Determine Tornado Ending Time	^	#	*	~	
616	1.1.1.5.7.3	**Determine Water Spout Location**	^	#	*	~	**%**
617	1.1.1.5.7.3.1	Measure Water Spout Movement Direction	^	#	*		
618	1.1.1.5.7.3.2	Measure Water Spout Movement Speed	^	#	*		
619	1.1.1.5.7.3.3	~~Determine Water Spout Intensity~~	^	#	*	~	
620	1.1.1.5.7.3.4	Determine Water Spout Beginning Time	^	#	*	~	
621	1.1.1.5.7.3.5	Determine Water Spout Ending Time	^	#	*	~	
622	~~1.1.1.5.8~~	~~**Observe Wake Vortex (WV) at Super-density Airports +**~~	~~^~~	~~#~~	~~*~~	~~~~	
623	~~1.1.1.5.8.1~~	~~Determine Wake Vortex Location at Super-density Airports~~	~~^~~	~~#~~	~~*~~	~~~~	
624	~~1.1.1.5.8.2~~	~~Determine WV Horizontal Displacement at Super-density Airports~~	~~^~~	~~#~~	~~*~~	~~~~	
625	~~1.1.1.5.8.3~~	~~Determine WV Vertical Displacement at Super-density Airports~~	~~^~~	~~#~~	~~*~~	~~~~	
626	~~1.1.1.5.8.4~~	~~Determine WV Dissipation at Super-density Airports~~	~~^~~	~~#~~	~~*~~		
627	1.1.1.5.9	**Observe Well-Developed[10] Dust/Sand Whirls +**					
628	1.1.1.5.9.1	Determine Location of Well-Developed Dust Whirls	^	#		~	
629	1.1.1.5.9.2	Determine Location of Well-Developed Sand Whirls					
630	1.1.1.5.9.3	Determine Beginning Time of Well-Developed Dust/Sand Whirls					
631	1.1.1.5.9.4	Determine Ending Time of Well-Developed Dust/Sand Whirls					
632	1.1.1.5.10	**Determine Location of Sandstorms**	^	#	*	~	
633	1.1.1.5.10.1	Determine Horizontal Extent of Sandstorms					
634	1.1.1.5.10.2	Determine Vertical Extent of Sandstorms					
635	1.1.1.5.10.3	Determine Beginning Time of Sandstorms					
636	1.1.1.5.10.4	Determine Ending Time of Sandstorms					
637	1.1.1.5.11	**Determine Location of Dust storms**	^	#	*	~	
638	1.1.1.5.11.1	Determine Horizontal Extent of Dust Storms					
639	1.1.1.5.11.2	Determine Vertical Extent of Dust Storms					
640	1.1.1.5.11.3	Determine Beginning Time of Dust Storms					
641	1.1.1.5.11.4	Determine Ending Time of Dust Storms					
642	1.1.1.5.12	**Determine Location of Fog Banks**	^	#	*	~	
643	1.1.1.5.12.1	Determine Horizontal Extent of Fog Banks					
644	1.1.1.5.13	**Observe Frost +**	^				
645	1.1.1.5.13.1	Determine Horizontal Extent of Frost	^				**%**
646	1.1.1.5.13.2	Determine Beginning Time of Frost					
647	1.1.1.5.13.3	Determine Ending Time of Frost					
648	~~**1.1.1.5.14**~~	~~**Observe Weather Conditions that Contribute to Braking Action**~~	~~^~~	~~#~~			

[10] Well-developed dust/sand whirls = Ensemble of particles of dust or sand, sometimes accompanied by small litter, raised from the ground in the form of a whirling column of varying height with a small diameter and approximately a vertical axis.

COORDINATION VERSION

1.1.1.6	—[Moved to USDT and expanded into 3 functions]**Observe Wind +**		^	#	*	
1.1.1.6.1	Measure Wind Direction	^	#	*		
1.1.1.6.2	Measure Wind speed	^	#	*		
1.1.1.6.2.1	Measure Wind Direction for Super-density Runways	^	#	*	~	
1.1.1.6.2.2	Measure Wind Speed for Super-density Runways	^	#	*	~	
1.1.1.6.2.3	Measure Variable Wind Speed	^	#		~	
1.1.1.6.2.4	Measure Variable Wind Direction	^	#		~	
1.1.1.6.3	**Determine Occurrence of Wind Gusts**	^	#		~	
1.1.1.6.3.1	Measure Wind Gust Direction	^	#		~	
1.1.1.6.3.2	Measure Wind Gust Speed	^	#		~	
1.1.1.6.3.3	Determine Time of Wind Gust	^	#			
~~1.1.1.6.4~~	~~**Determine Airport Wind [Moved to User DST]**~~	~~^~~	~~#~~		~~~~	
~~1.1.1.6.4.1~~	~~Measure Airport Wind Direction~~	~~^~~	~~#~~		~~~~	
~~1.1.1.6.4.2~~	~~Measure Airport Wind Speed~~	~~^~~	~~#~~		~~~~	
1.1.1.6.5	**Determine Occurrence of Wind Shift**					
1.1.1.6.5.1	Calculate Wind Shift	^	#	*	~	
1.1.1.6.5.2	Calculate Time of Wind Shift	^	#	*	~	
1.1.1.6.6	**Determine Occurrence of Peak Wind**	^	#			
1.1.1.6.6.1	Measure Peak Wind Speed	^	#			
1.1.1.6.6.2	Measure Peak Wind Direction	^	#			
1.1.1.6.6.3	Determine Time of Peak Wind	^	#			
1.1.1.6.7	~~**Determine Calm Wind**~~ [Not needed]	^	#			
1.1.1.6.8	**Determine Runway Winds**	^		*	~	
1.1.1.6.8.1	Measure Runway Threshold Wind Direction	^	#	*	~	
1.1.1.6.8.2	Measure Runway Threshold Wind Speed	^	#	*	~	
1.1.1.6.8.3	Measure Runway Mid-point Wind Direction	^	#		~	
1.1.1.6.8.4	Measure Runway Mid-point Wind Speed	^	#		~	
1.1.1.6.8.5	Measure Runway Departure Wind Direction	^	#	*	~	
1.1.1.6.8.6	Measure Runway Departure Wind Speed	^	#	*	~	
1.1.1.7	**Observe Surface Visibility +**	^	#	*	~	
~~1.1.1.7.1~~	~~Measure Surface Visibility~~ (Redundant)	~~^~~	~~#~~	~~*~~	~~~~	
1.1.1.7.2	Measure Tower Visibility	^	#	*	~	
~~**1.1.1.7.3**~~	~~Measure Airport Visibility~~ (Redundant)	~~^~~	~~#~~	~~*~~	~~~~	
1.1.1.7.4	Measure Prevailing Visibility	^	#	*	~	
1.1.1.7.4.1	Measure Variable Prevailing Visibility	^	#	*		
1.1.1.7.5	Measure Sector Visibility	^	#	*		
1.1.1.8	**Determine RVR**	^	#	*	~	
1.1.1.8.1	Measure RVR at Touchdown	^	#	*	~	
1.1.1.8.2	Measure RVR at Mid-point	^	#		~	
1.1.1.8.3	Measure RVR at Rollout	^	#		~	

COORDINATION VERSION

689	1.1.1.8.4	Calculate RVR 10-Minute Average[11]	^	#	*	
690	**1.1.1.9**	**Observe Pressure Parameters +**	^	#		
691	1.1.1.9.1	Measure Barometric Pressure	^	#		
692	1.1.1.9.2	Calculate Sea Level Pressure	^	#		
693	1.1.1.9.3	Calculate Station Pressure	^	#		~
694	1.1.1.9.4	Calculate Pressure Change	^	#		
695	1.1.1.9.5	Calculate Pressure Tendency	^	#		
696	1.1.1.9.5.1	Determine Pressure Rising Rapidly (≥ 0.06 “/ hour)	^	#		
697	1.1.1.9.5.2	Determine Pressure Falling Rapidly (≥ 0.06 “/ hour)	^	#		
698	1.1.1.9.5.3	Calculate 3-Hour Pressure Tendency	^	#		
699	1.1.1.9.6	Calculate Airport Altimeter Setting	^	#		~
700	1.1.1.9.7	Calculate Airport Density Altitude	^	#		~ %
701	**1.1.1.10**	**Observe Sky Conditions +**	^	#	*	
702	1.1.1.10.1	Determine Sky Cover	^	#	*	~
703	1.1.1.10.1.1.	Calculate Sky Cover as "Few", "Scattered", "Broken" or "Overcast"				
704	1.1.1.10.2	Measure Each Cloud Layer Height	^	#	*	~
705	1.1.1.10.2.1	Determine Lowest “Few” Cloud Layer	^	#		
706	1.1.1.10.2.2	Determine Lowest “Broken” Cloud Layer	^	#	*	~
707	1.1.1.10.2.3	Determine “Overcast” Cloud Layer	^	#	*	~
708	1.1.1.10.2.4	Determine Lowest “Scattered” Cloud Layer	^	#		
709	1.1.1.10.2.5	Determine 2nd Lowest “Scattered” Cloud Layer	^	#	*	
710	1.1.1.10.2.6	Determine 2nd Lowest “Broken” Cloud Layer	^	#		
711	1.1.1.10.2.7	Determine Highest “Broken” Cloud Layer	^	#		
712	1.1.1.10.2.8	Determine Highest “Scattered” Cloud Layer	^	#		
713	1.1.1.10.3	Determine Cloud Ceiling	^	#	*	~
714	1.1.1.10.3.1	Measure Lowest Cloud Ceiling Height	^	#	*	~
715	1.1.1.10.3.2	Measure Variable Cloud Ceiling Height	^	#		
716	1.1.1.10.4	Determine Cloud Type	^	#	*	
717	1.1.1.10.5	Determine Maximum Altitude of Cloud Tops	^	#	*	
718	**1.1.1.11**	**Observe Airport Surface Temperature +**				
719	1.1.1.11.1	Measure Surface Temperature	^	#		
720	1.1.1.11.1.1	Determine Surface Maximum Temperature	^	#		%
721	1.1.1.11.1.2	Measure Surface Dewpoint Temperature	^	#		
722	1.1.1.11.1.3	Determine Surface Minimum Temperature	^	#		
723	1.1.1.11.2	Measure Runway Surface Temperature	^	#		
724	1.1.1.11.3	Calculate Relative Humidity				
725	**1.1.1.12**	**Observe Ocean Surface Conditions +**	^	#		
726	1.1.1.12.1	Determine Ocean Wave Height (feet)	^	#		

[11] RVR 10-minute average—for long-line distribution (e.g., International Civil Aviation Organization [ICAO]) and dispatch planning.

COORDINATION VERSION

727	1.1.1.12.2	Determine Ocean Swell Height (feet)	^	#	
728	1.1.1.12.3	Determine Ocean Wave Direction	^	#	
729	1.1.1.12.4	Determine Ocean Swell Direction	^	#	
730	1.1.1.12.5	Determine Ocean Surface Temperature			
731	1.1.1.12.6	Determine Ocean Ice Obstructions			
732	**1.1.1.13**	**Observe Large Lake[12] Surface Conditions +**	^		
733	1.1.1.13.1	Determine Large Lake Wave Height	^	#	
734	1.1.1.13.2	Determine Large Lake Wave Direction	^	#	
735	1.1.1.13.3	Determine Large Lake Surface Temperature			
736	1.1.1.13.4	**Observe Atmospheric Conditions Aloft[13] +**	^	#	*
737	**1.1.1**	**Observe Winds Aloft**	^	#	~
738	1.1.1.1	Measure Wind Direction Aloft	^	#	~
739	1.1.1.2	Measure Wind Speed Aloft	^	#	~
740	1.1.1.3	Determine Compression[14] Winds	^	#	~
741	**1.1.2**	**Observe Obscurations (to Visibility) Aloft +**	^	#	
742	1.1.2.1	Determine Slant Range Visibility in Statute Miles for			
743		Approach/Departure Corridors at Super-density Airports	^	#	*
744	1.1.2.2	Determine Location of Smoke Aloft	^	#	*
745	1.1.2.3	Determine Location of Blowing Dust Aloft	^	#	*
746	1.1.2.4	Determine Location of Mist Aloft [Check 3rd & 4th type sent to Tom]			
747	1.1.2.5	Determine Location of Haze Aloft			
748	1.1.2.6	Determine Maximum Altitude of Surface Obscuration			
749	**1.1.3**	**Observe Temperature Aloft +**	^		
750	1.1.3.1	Measure Atmospheric Temperature Aloft	^		
751	1.1.3.2	Measure Atmospheric Dewpoint Aloft	^		
752	1.1.3.3	Calculate Atmospheric Relative Humidity Aloft			
753	**1.1.4**	**Observe Precipitation Aloft +**	^	#	
754	1.1.4.1	**Observe Liquid Precipitation**	^	#	
755	1.1.4.1.1	Determine Horizontal Extent of Rain	^	#	
756	1.1.4.1.2	Determine Vertical Extent (FL) of Rain [Used flight levels in M]	^	#	
757	1.1.4.1.3	Measure Rain Intensity	^	#	*
758	1.1.4.1.4	Determine Horizontal Extent of Drizzle	^	#	
759	1.1.4.1.5	Determine Vertical Extent (FL) of Drizzle [Used flight levels in M]	^	#	
760	1.1.4.1.6	Determine Location of Virga	^		
761	1.1.4.1.7	Determine Location of Rain			
762	1.1.4.1.8	Determine Location of Drizzle			
763	1.1.4.2	**Observe Solid Precipitation Aloft +**			

[12] Large Lake = Large body of water with sufficient fetch to generate appreciable wave/swell height.
[13] Aloft = Over airports above 10,000 feet; elsewhere, above 6,000 feet (both up to 100 kft).
[14] Compression Winds = Related to wind change in speed/direction with height over/near airports; vertical wind profile.

COORDINATION VERSION

1.1.4.2.1	Determine Horizontal Extent of Hail	^	#	*		
1.1.4.2.2	Determine Vertical Extent (FL) of Hail [Used flight levels in M]	^	#	*		
1.1.4.2.3	Measure Hail Density	^	#	*		
1.1.4.2.4	Determine Location of Snow Pellets	^	#	*		
1.1.4.2.4.1	Determine Horizontal Extent of Snow Pellets					
1.1.4.2.4.2	Determine Vertical Extent of Snow Pellets [Used flight levels in M]					
1.1.4.2.5	Determine Location of Snow	^	#			
1.1.4.2.6	Determine Horizontal Extent of Snow	^	#			
1.1.4.2.7	Determine Vertical Extent (FL) of Snow [Used flight levels in M]	^	#			
1.1.4.2.8	Measure Snowfall Intensity	^	#			
1.1.4.2.9	Determine Horizontal Extent of Ice Pellets	^	#			
1.1.4.2.9.1	Determine Vertical Extent of Ice Pellets					
1.1.4.2.10	Measure Ice Pellet Intensity	^	#			
1.1.4.2.11	Determine Horizontal Extent of Ice Crystals	^				
1.1.4.2.12	Determine Vertical Extent (FL) of Ice Crystals [Used flight levels in M]				^	
~~1.1.4.3~~	~~**Observe Freezing Precipitation Aloft + [Merged with In-flight Icing 1.1.2.5.4]**~~					
~~1.1.4.3.1~~	~~Determine Horizontal Extent of Freezing Rain~~	~~^~~	~~#~~	~~*~~	~~~~	
~~1.1.4.3.2~~	~~Determine Vertical Extent (FL) of Freezing Drizzle~~	~~^~~	~~#~~	~~*~~	~~~~	
~~1.1.4.3.3~~	~~Determine Altitude of Freezing Level~~	~~^~~	~~#~~			
~~1.1.4.3.3.1~~	~~Determine Horizontal Extent of Supercooled Liquid Droplets~~	~~^~~	~~#~~	~~*~~		
~~1.1.4.3.3.2~~	~~Determine Vertical Extent (FL) of Supercooled Liquid Droplets~~	~~^~~	~~#~~	~~*~~		
1.1.4.4	Determine Beginning time of Precipitation Aloft					
1.1.4.5	Determine Ending time of Precipitation Aloft					
1.1.5	**Observe Other Atmospheric Conditions Aloft +**					
1.1.5.1	**Observe Volcanic Ash Cloud Aloft +**					
1.1.5.1.1	Determine Volume of Air Containing Volcanic Ash (FAA Order)	^	#	*		
1.1.5.1.2	Measure Density of Volcanic Ash	^	#	*		
1.1.5.1.3	Determine Layer(s) Where Volcanic Ash Is Most Concentrated (FAA Order)	^	#	*		
1.1.5.2	**Determine Maximum Altitude of TS Cloud Tops**	^	#	*		
1.1.5.3	**Determine Minimum Altitude of TS Cloud Base**	^	#	*	~	
1.1.5.4	**Observe In-Flight Icing +**	^	#	*	~	
1.1.5.4.1	Determine Horizontal Extent of In-flight Icing	^	#	*	~	
1.1.5.4.2	Determine Vertical Extent of In-flight Icing	^	#		~	
1.1.5.4.3	Determine Type of In-flight Icing (i.e., Rime, Clear, SLD)	^	#		~	
1.1.5.4.4	Determine Altitude of Freezing Level					
1.1.5.4.5	Determine Horizontal Extent of Supercooled Liquid Droplets	^	#	*		
1.1.5.4.6	Determine Vertical Extent (FL) of Supercooled Liquid Droplets	^	#	*		
1.1.5.4.7	Determine Location of In-flight Icing					
1.1.5.4.8	Determine Beginning Time of Supercooled large droplets Aloft					
1.1.5.4.9	Determine Ending Time of Supercooled large droplets Aloft					
1.1.5.4.10	Determine Beginning Time of In-flight Icing					

COORDINATION VERSION

1.1.5.4.11 Determine Ending Time of In-flight Icing
~~1.1.5.4.12 Determine Intensity of In-Flight Icing Accumulation by Aircraft Type~~
1.1.5.5 **Determine 3-D Extent of Turbulence** ^ # * ~
1.1.5.5.1 Measure Intensity of Turbulence ^ # * ~
1.1.5.5.2 Determine Horizontal Extent of Turbulence
1.1.5.5.3 Determine Vertical Extent of Turbulence
1.1.5.5.4 Determine Location of Turbulence
1.1.5.5.5 Determine Beginning Time of Turbulence
1.1.5.5.6 Determine Ending Time of Turbulence
1.1.5.5.7 Determine Type of Turbulence
~~1.1.5.5.8 Determine Intensity Turbulence by Aircraft Type~~
1.1.5.6 **Observe Cloud Lightning**
1.1.5.6.1 Observe Inter-Cloud Lightning
~~1.1.5.6.1.1 Measure Frequency of Inter-Cloud Lightning~~
1.1.5.6.1.2 Determine Location of Inter-Cloud Lightning
1.1.5.6.1.3 Determine Polarity of Inter-Cloud Lightning
1.1.5.6.1.4 Determine Peak Current of Inter-Cloud Lightning
1.1.5.6.2 Observe Intra-Cloud Lightning
~~1.1.5.6.2.1 Measure Frequency of Intra-Cloud Lightning~~
1.1.5.6.2.2 Determine Location of Intra-Cloud Lightning ^ # * ~
1.1.5.6.2.3 Determine Polarity of Intra-Cloud Lightning
1.1.5.6.2.4 Determine Peak Current of Intra-Cloud Lightning
1.1.5.6.3 Observe Cloud-to-Air Lightning
~~1.1.5.6.3.1 Measure Frequency of Cloud-to-Air Lightning~~
1.1.5.6.3.2 Determine Location of Cloud-to-Air Lightning
1.1.5.6.3.3 Determine Polarity of Cloud-to-Air Lightning
1.1.5.6.3.4 Determine Peak Current of Cloud-to-Air Lightning
1.1.5.7 **Observe Space Wx Parameters +** ^ #
1.1.5.7.1 **Observe Solar Radiation Activity (e.g., Solar Flares, Coronal Mass Ejections)**
1.1.5.7.1.1 Determine Magnitude of Solar Radiation Impinging on Atmosphere ^ *
1.1.5.7.1.2 Determine Time of Onset of Solar Radiation Activity ^ # *
1.1.5.7.1.3 Calculate Duration of Solar Radiation Activity ^ # *
1.1.5.7.2 **Determine Regions (Space, Polar, Mid-Latitude) Where High Energy (> 100 MeV) of Solar Radiation Exists** ^ # *
1. Determine Time of Onset of High Energy Solar Radiation
2. Calculate Duration of High Energy Solar Radiation
2. Determine Regions (Space, Polar, Mid-Latitude) Where Moderate Energy (> 10 MeV) of Solar Radiation Exists ^ # *
1. Determine Onset of Moderate Energy Solar Radiation
2. Calculate Duration of Moderate Energy Solar Radiation
1.1.5.7.3 **Observe Geomagnetic Storm Activity +**

COORDINATION VERSION

1.1.5.7.3.1 Determine Location of Geomagnetic Storm Activity ^ # *
1.1.5.7.3.2 Determine Onset of Geomagnetic Storm Activity ^ # *
1.1.5.7.3.3 Calculate Duration of Geomagnetic Storm Activity ^ # *
1.1.5.8 **Measure Atmospheric Pressure Aloft**
1.1.5.9 ~~Observe Hurricanes/Typhoons~~ [Moved to WESDST]
~~1.1.5.9.1 Determine Hurricane/Typhoon Category~~
~~1.1.5.9.2 Determine Hurricane/Typhoon Category Change~~
~~1.1.5.9.3 Calculate Hurricane/Typhoon Movement Direction~~
~~1.1.5.9.4 Calculate Hurricane/Typhoon Movement Speed~~

2 Catalog Weather Data
2.1 Obtain Measurement
2.2 Obtain Location
2.3 Geo-reference Location
2.4 Obtain Date Time Group
2.5 Create Observation

3 Analyze Weather Data
3.1 Collect Cataloged Observations
3.2 Perform Quality Control
3.3 Analyze Observations
3.4 Analyze Forecasts

4 Run Models/Algorithms
4.1 Ingest Observations
4.2 Quality Control Observations
4.3 Integrate ground-, space- and airborne observations
4.4 Interpolate observations to grid points
4.5 Run Model
4.6 Run Algorithms
4.7 Create 4-D Weather SAS
4.8 Write Output

The following list includes the functions and subfunctions for Forecast Weather F 1.1.5 as shown in Figure B-3. Because the majority of forecasts will be probabilistic, the following identifies those that are very likely to be probabilistic with a WP (With Probability). In addition, in the interest of brevity, we eliminated in this list the "F 1.1" that precedes all of the Forecast Weather

COORDINATION VERSION

function and subfunction numbers. For example, the hierarchy for "F 1.1.5 Forecast Atmospheric and Space Conditions" (in Figure B-3) becomes "5 Forecast Atmospheric and Space Conditions":

5 Forecast Atmospheric and Space Conditions (With Probability (WP)) ^ # *

5.1 Forecast Surface Atmospheric Conditions (WP) ^ # * ~ %

5.1.1 Determine Terminal IFR Conditions from forecast ceiling and surface visibility ^ # * ~

5.1.1.1 Determine Location of IFR Conditions from Forecast Ceiling and Surface Visibility

5.1.1.2 Determine Horizontal Extent of IFR Conditions from Forecast Ceiling and Surface Visibility

5.1.1.3 Determine Beginning Time of IFR Conditions from Forecast Ceiling and Surface Visibility

5.1.1.4 Determine Ending Time of IFR Conditions from Forecast Ceiling and Surface Visibility

5.1.2 Forecast Frost (WP) ^ %

5.1.2.1 Forecast Location of Frost (WP)

5.1.2.2 Determine Beginning Time of Frost from Forecasts of Frost

5.1.2.3 Determine the Ending Time of Frost from Forecasts of Frost

5.1.3 Forecast Surface Winds (WP) ^ # *

5.1.3.1 Forecast Wind Direction (WP) ^ # * ~

5.1.3.2 Forecast Wind Speed (WP) ^ # * ~

5.1.3.3 Forecast Occurrence of Variable Winds (WP) ^ # *

5.1.3.4 Determine Occurrence of Wind Shifts from Forecast Surface Wind Direction and Speed ^ # * ~

5.1.3.4.1 Determine Duration of Wind Shifts from Calculated Occurrences of Windshift ^ # *

5.1.3.5 Calculate Peak Winds from Forecast Surface Wind Direction and Speed ^ #

5.1.3.6 Calculate Location of Wind Gusts from Forecast Surface Wind Direction and Speed ^ # *

5.1.3.6.1 Forecast Wind Gust Speed (WP) ^ # *

5.1.3.6.2 Forecast Wind Gust Direction (WP) ^ # * ~

5.1.3.7 ~~Forecast Calm Winds (WP)~~ (Not needed) ^ #

5.1.3.8 Determine Runway Winds from Forecast Surface Wind Direction and Speed ^ # *

5.1.3.8.1 Determine Winds at Runway Threshold from Forecast Surface Wind Direction and Speed ^ #

5.1.3.8.2 Determine Winds at Runway Departure from Forecast Surface Wind Direction and Speed ^ #

5.1.4 Forecast Airport Surface Temperature (WP) ^ #

5.1.4.1 Forecast Airport Surface Dewpoint Temperature (WP) ^ #

5.1.4.2 Determine Maximum Airport Surface Temperature from Forecast Temperature ^ %

5.1.4.3 Forecast Runway Temperature ^

COORDINATION VERSION

5.1.4.4 Calculate Surface Relative Humidity from Forecast Temperature and Dewpoint ^

5.1.4.5 Determine Airport Minimum Surface Temperature from Forecast Temperature

5.1.5 Forecast Airport Surface Obscurations (WP) ^ # * %

5.1.5.1 Determine Areas of Widespread Low Visibility from Forecast Surface Visibilities and Ceiling ^ # *

5.1.5.1.1 Forecast Airport Location of Fog (WP) ^ # * ~ %

5.1.5.1.2 Forecast Airport Location of Haze (WP) ^ # * ~ %

5.1.5.1.3 Forecast Airport Location of Smoke (WP) ^ # * ~ %

5.1.5.1.4 Forecast Airport Location of Volcanic Ash (WP) ^ # * ~ %

5.1.5.1.5 Forecast Airport Location of Mist (WP)

5.1.5.1.6 Forecast Airport Location of Dust (WP)

5.1.5.1.7 Forecast Airport Location of Sand (WP)

5.1.5.1.8 Forecast Airport Location of Blowing Sand (WP)

5.1.5.1.9 Forecast Airport Location of Drifting Sand (WP)

5.1.5.1.10 Forecast Airport Location of Freezing Fog (WP)

5.1.5.2 Forecast Obscuration Types from Surface to 6,000 ft. MSL for En Route Airspace (WP) ^ # *

5.1.5.3 Determine Top of Airport Surface Obscurations from Forecast Surface Obscuration Locations, Obscuration Types, and Surface Visibility ^ #

5.1.5.4 Determine Horizontal Extent of Surface Obscuration from Forecast Surface Obscuration Locations at ^ # * ~ %

5.1.5.5 Determine Low Clouds at Super-density Airports from Forecasts of Sky Conditions ^ # * ~

5.1.5.6 Determine Ceilings at Super-density Airports from Forecasts of Sky Conditions ^ # * ~

5.1.5.7 Forecast Low Drifting Snow at Airport (WP) ^ # %

5.1.5.8 Forecast Blowing Snow at Airport (WP) ^ # %

5.1.5.9 Forecast Blowing Spray at Airport (WP) ^ #

5.1.5.10 Forecast Freezing Fog at Airport. (WP)

5.1.5.11 Determine Beginning Time of Forecast Obscurations at Surface of Selected Terminal Airspace

5.1.5.12 Determine Ending Time of Forecast Obscurations at Surfaces of Selected Terminal Airspace.

5.1.5.13 Forecast vertical visibility

5.1.6 Forecast Location of Precipitation +

5.1.6.1 **Forecast Location of Liquid Precipitation +**

5.1.6.1.1 Determine Horizontal Extent of Liquid Precipitation from forecast locations of liquid precipitation ^ # * ~

5.1.6.1.2 Forecast Amount (inches) of Liquid Precipitation (WP) ^ # * ~

5.1.6.1.3 Forecast Rain Rate (WP) (inches/hour) ^ # * ~ %

COORDINATION VERSION

5.1.6.1.3.1 Calculate Rain Intensity from Forecast Rain Rate

5.1.6.1.4 Determine Occurrence of Moderate or Greater Rain Showers from forecast rain intensity ^ # * ~

5.1.6.1.5 Determine Liquid Precipitation Movement from forecast location of liquid precipitation ^ # * ~

5.1.6.1.5.1 Determine Direction of Precipitation Movement from forecast location of precipitation ^ # * ~

5.1.6.1.5.2 Determine Speed of Precipitation Movement from forecast location of precipitation ^ # * ~

~~5.1.6.1.6 Determine Beginning Time of Liquid Precipitation from forecast liquid precipitation~~ Up leveled ~~^ # * ~~

5.1.6.1.7 ~~Determine Ending Time of Liquid Precipitation from forecast liquid precipitation~~ ^ # * ~

5.1.6.2 **Forecast Location of Freezing Precipitation Type** (WP) ^ # * ~ %

5.1.6.2.1 Forecast Location of Freezing Rain (WP) ^ # * ~ %

5.1.6.2.2 Forecast Location of Freezing Drizzle (WP) ^ # * ~ %

5.1.6.2.3 Forecast Ice Accretion Rate (WP) ^ # ~ %

5.1.6.2.4 Forecast Surface Icing Accumulation (WP) ^ # ~ %

~~5.1.6.2.5 Determine Beginning Time of Freezing Precipitation ^ # * ~ %~~

~~5.1.6.2.6 Determine Ending Time of Freezing Precipitation~~ Up leveled ~~^ # * ~ %~~

5.1.6.2.7 Determine Horizontal Extent of Freezing Precipitation from forecast location of freezing precipitation

5.1.6.2.8 Calculate Freezing Precipitation intensity from forecast ice accretion rate

5.1.6.2.9 Determine water equivalent from forecast surface icing accumulation

5.1.6.2.10 Determine vertical extent of freezing precipitation (WP)

5.1.6.3 **Forecast Location of Solid Precipitation** (WP) ^ # * ~ %

5.1.6.3.1 **Forecast Location of Snow (WP)** ^ # * ~ %

5.1.6.3.1.1 Forecast Snow Intensity (WP) (inches/hour) ^ # * ~ %

5.1.6.3.1.2 Forecast Snowfall Accumulation ^ # * %

5.1.6.3.1.3 ~~Forecast Snow Shower (WP)~~ ^ # * ~ %

5.1.6.3.1.4 Forecast Liquid Water Equivalent of Snowfall Accumulation (WP) ^ # * ~ %

~~5.1.6.3.1.5 Determine Beginning Time of Snowfall~~ Up leveled ~~^ # * ~ %~~

~~5.1.6.3.1.6 Determine Ending Time of Snowfall ^ # * ~ %~~

5.1.6.3.2 **Forecast Location of Hail** (WP) ^ # * ~

5.1.6.3.2.1 Forecast Hail size (WP) ~~½ inch or greater~~ ^ # * ~ %

5.1.6.3.2.2 Determine Horizontal Extent of Hail from forecast location of hail ^ # * ~

5.1.6.3.2.3 ~~Determine the Beginning Time of Hail~~ [Up leveled]

~~5.1.6.3.2.4 Determine the Ending Time of Hail~~

5.1.6.3.3 **Forecast Location of Ice Pellets** (WP) ^ # * ~

5.1.6.3.3.1 Determine Horizontal Extent of Ice Pellets from forecast location of ice pellets ^ # * ~

COORDINATION VERSION

5.1.6.3.3.2 Forecast Ice Pellet Intensity (WP) ^ # * ~
5.1.6.3.4 Forecast Location of Snow Pellets (WP) ^ # ~
5.1.6.3.5 Forecast Location of Ice Crystals (WP) ^ # * ~
5.1.6.3.6 Forecast water equivalent of solid precipitation over time increments (inches/hour) (WP) ^ # * ~ %
5.1.6.4 Determine Beginning Time of Precipitation from Forecast of Precipitation Location
5.1.6.5 Determine Ending time of Precipitation from Forecast of Precipitation Location
5.1.7 Forecast Surface Visibility (WP)
5.1.7.1 ~~**Forecast Airport Visibility**~~ ^ # * ~
5.1.7.2 **Forecast RVR (WP)** ^ # * ~
5.1.8 Forecast Sky Conditions (WP) ^ # ~
5.1.8.1 Determine Sky cover from Forecast Sky Conditions ^ # ~
5.1.8.2 Determine Dominant Cloud Layer Base Heights from Forecast Sky Conditions ^ # ~
5.1.8.3 Calculate Ceiling from Forecast Sky Conditions ^ # * ~
5.1.8.3.1 Determine Horizontal Extent of Cloud Ceiling from Calculated Ceilings ^ #
~~5.1.8.4 Forecast Cloud Types^ # ~~
5.1.8.5 Derive Cloud Stratification (Types versus layers) ^ # ~
5.1.9 Forecast Ocean Surface Conditions ^ #
5.1.9.1 Forecast Ocean Wave and Swell Heights (WP) ^ #
5.1.9.1.1 Forecast Ocean Wave Heights (WP)
5.1.9.1.2 Forecast Ocean Swell Heights (WP)
5.1.9.2 Forecast Ocean Wave and Swell Direction (WP) ^ #
5.1.9.2.1 Forecast Ocean Wave Direction (WP)
5.1.9.2.2 Forecast Ocean Swell Direction (WP)
5.1.9.3 Forecast Ocean Surface Temperature (WP)
5.1.10 Forecast Large Lake Surface Conditions
5.1.10.1 Forecast Large Lake Wave Heights (WP) ^ #
5.1.10.2 Forecast Large Lake Wave l Direction (WP) ^ #
~~5.1.10.3 Forecast Large Lake Wave Direction (WP)~~
5.1.10.4 ~~Forecast Large Lake Swell Direction (WP)~~ (based on reference)
5.1.10.5 Forecast Large Lake Surface Temperature (WP)
5.1.11 Forecast Other Weather
5.1.11.1 **Forecast Wind Direction at Surface ~~to 100 kft~~ at Other Than Airports** ^ #
5.1.11.2 **Forecast Wind Speed at Surface ~~to 100 kft~~ at Other Than Airports** ^ #
5.1.11.3 **Construct Position of Jet Stream** from Forecast Wind Speed and Direction ^ # *
5.1.11.4 Forecast Temperature at Surface ~~to 60 kft~~ at Other Than Airports ^ #

COORDINATION VERSION

5.1.11.5 **Derive Location of Volume Identified as a Thunderstorm from Forecast lightning, clouds, precipitation, winds, mesocyclone, funnel clouds, tornados, and gust fronts** **^ # * ~**

5.1.11.5.1 Calculate Direction of Movement of Volume Identified as Thunderstorm from Forecast Wind Direction **^ # * ~ %**

5.1.11.5.2 Calculate Speed of Movement of Volume Identified as Thunderstorm from Forecast Wind Speed **^ # * ~ %**

5.1.11.5.3 Derive Location of Thunderstorm Cell from Forecast Lightning, Sky Condition, and Precipitation **^ # * ~ %**

5.1.11.5.4 Calculate intensity of thunderstorm cell from forecast precipitation and winds**^ # * ~ %**

5.1.11.5.5 Determine horizontal extent of precipitation associated with thunderstorm from forecast location of precipitation **^ # * ~**

5.1.11.5.6 Calculate precipitation accumulation associated with thunderstorms from forecast amount of liquid precipitation **^ # * ~**

5.1.11.5.7 Forecast Locations of Convective Initiation (WP) **^ # ***

5.1.11.5.8 Forecast Locations of Thunderstorm Growth (WP) **^ # * ~**

5.1.11.5.9 Forecast Locations of Thunderstorm Decay (WP) **^ # * ~**

5.1.11.5.10 Calculate duration of thunderstorm from derived locations of thunderstorms.

5.1.11.5.10.1 Determine Beginning time of thunderstorms from derived locations of thunderstorms.

5.1.11.5.10.2 Determine ending time of thunderstorms from derived locations of thunderstorms.

5.1.11.6 **Forecast Location of Lightning** **^ # * ~ %**

5.1.11.6.1 Determine Horizontal Extent of Intra-Cloud Lightning from forecast location of lightning **^ # * ~ %**

5.1.11.6.2 Determine Vertical Extent (FL) of Intra-Cloud Lightning from forecast location of lightning **^ # * ~**

5.1.11.6.3 Determine Horizontal Extent of Inter-Cloud Lightning from forecast location of lightning **^ # * ~ %**

5.1.11.6.4 Determine Vertical Extent (FL) of Inter-Cloud Lightning from forecast location of lightning **^ # * ~**

5.1.11.6.5 Forecast non-airport Location(s) of Groundstroke Lightning (WP) **^ # * ~ %**

~~5.1.11.6.6 Determine When Lightning Is Imminent from Forecast Location of Lightning~~[15] ~~**^ # * ~ %**~~

5.1.11.6.7 Determine Beginning Time of Lightning from Forecast Location of Lightning

5.1.11.6.8 Determine Ending Time of Lightning from Forecast Location of Lightning

5.1.11.6.9 Forecast Polarity of Lightning

5.1.11.7 **Forecast Location of Mesocyclones (WP)** **^ # * ~**

5.1.11.7.1 Calculate Mesocyclone Movement Speed from Forecast Wind Speed **^ # * ~**

5.1.11.7.2 Calculate Mesocyclone Movement Direction from Forecast Wind Direction**^ # * ~**

[15] Imminent = Lightning expected within 5 to 10 minutes.

COORDINATION VERSION

5.1.11.7.3 Calculate Mesocyclone Duration from Derived Beginning and Ending Times

5.1.11.7.3.1 Determine Beginning Time of Mesocyclones from Forecast Location of Mesocyclones

5.1.11.7.3.2 Determine Ending Time of Mesocyclones from Forecast Location of Mesocyclones

5.1.11.8 **Forecast occurrence of Low-Level Wind Shear/Microburst activity (WP)** ^ # * ~

5.1.11.8.1 Forecast location of Low-Level Wind Shear (WP)

5.1.11.8.2 Forecast location of Microburst (WP)

5.1.11.9 **Forecast Location of Liquid Stratiform Precipitation** ^ # * ~

5.1.11.10 Determine Horizontal Extent of Liquid Stratiform Precipitation from Forecast Location of Liquid Stratiform Precipitation ^ # * ~

5.1.11.11 Determine Beginning Time of Liquid Stratiform Precipitation from Forecast Location of Liquid Stratiform Precipitation ^ # * ~

5.1.11.12 Determine Ending Time of Liquid Stratiform Precipitation from Forecast Location of Liquid Stratiform Precipitation ^ # * ~

5.1.12 Forecast Location of Solid Stratiform Precipitation ^ # * ~ %

5.1.12.1 Determine Horizontal Extent of Solid Stratiform Precipitation from Forecast Location of Solid Stratiform Precipitation ^ # * ~ %

5.1.12.2 Determine Beginning Time of Solid Stratiform Precipitation ^ # * ~ %

5.1.12.3 Determine Ending Time of Solid Stratiform Precipitation ^ # * ~ %

5.1.13 ~~**Determine Wake Vortex (WV) at Super-density Airports from Forecast Wind Speed and Direction** ^ # * ~~

~~5.1.13.1 Determine WV Displacement at Super-density Airports from Forecast Wind Speed and Direction ^ # *~~

5.1.13.2 ~~Determine WV Dissipation at Super-density Airports from Forecast Wind Speed and Direction ^ # *~~ **[Moved to User DST]**

5.1.14 ~~**Determine location of Hurricanes/Typhoons from forecast sea surface wind speed and direction+** ^ # *~~

5.1.14.1 ~~Determine Hurricane/Typhoon Category from forecast wind speed ^ # **~~ **[Moved function 5.1.14 to Cube]**

~~5.1.14.2~~

~~5.1.14.3 Determine Hurricane/Typhoon Category Changes from forecast sea surface wind speed and direction ^ # *~~

~~5.1.14.4 Calculate Hurricane/Typhoon Movement Speed from determination of forecast locations of hurricane/typhoon ^ # *~~

5.1.14.5 ~~Calculate Hurricane/Typhoon Movement Direction from determination of forecast locations of hurricane/typhoon~~ ^ # *

5.1.15 Forecast Pressure

5.1.15.1 **Forecast Altimeter Setting at Surface of Selected Terminal Airspace**

5.2 Forecast Weather Aloft ^ # *

5.2.1 Forecast Winds Aloft ^ # ~

5.2.1.1 Forecast Wind Direction Aloft (WP) ^ #

COORDINATION VERSION

5.2.1.2 Forecast Wind Speed Aloft (WP) ^ #

5.2.1.3 Determine Wind Compression profile to 27 Kft from Forecast Winds Aloft for Selected Terminal Airspaces ^ # * ~

5.2.1.4 Forecast Vertical Wind Profile up to 100 Kft for Spaceports ^ #

5.2.2 Forecast Location of In-flight Icing (WP) ^ # * ~

5.2.2.1 Determine Horizontal Extent of In-flight Icing from Forecast Location of In-flight Icing ^ # * ~

5.2.2.2 Determine Vertical Extent of In-flight Icing from Forecast Location of In-flight icing ^ # * ~

~~5.2.2.3 Determine Accretion rate of In-flight Icing Accumulation by Aircraft Type from Forecast Location of In-flight Icing, Precipitation Aloft, and Forecast Location of supercooled large droplets ^ # * ~~

5.2.2.4 Forecast Location of Supercooled Large Droplets (WP) ^ # * ~

5.2.2.4.1 Determine Horizontal Extent of Supercooled Large Droplets from Forecast Location of Supercooled Liquid Droplets ^ # * ~

5.2.2.4.2 Determine Vertical Extent of Supercooled Large Droplets from Forecast Location of Supercooled Liquid Droplets ^ # * ~

5.2.2.5 ~~Determine the Beginning Time of In-flight Icing~~ {Duplicate} ^ # *

5.2.2.6 Determine beginning time of in-flight icing from forecast location of in-flight icing

5.2.2.7 Determine beginning time of supercooled liquid droplets from forecast location of supercooled liquid water droplets

5.2.2.8 Determine Ending Time of in-flight icing from forecast location of in-flight icing

5.2.2.9 Determined ending time of supercooled liquid droplets from forecast location of supercooled liquid water droplets

5.2.3 Forecast Location of Clouds (WP)

5.2.3.1 Determine Flight Level of Cloud Tops (Above Echo Tops) from forecast location of clouds ^ # *

5.2.3.2 Determine Height of Cloud Layer Bases from forecast location of clouds ^ # * ~

5.2.3.3 Determine Cloud Layer Thickness from forecast location of clouds ^ # *

5.2.3.4 Determine Beginning Time of Sky Conditions from forecast location of clouds

5.2.3.5 Determine the Ending Time of Sky Conditions from forecast location of clouds

5.2.4 Forecast Locations of Obscurations (WP) Aloft *

5.2.4.1 Derive Slant Range Visibility from Forecast Obscurations Aloft for Approach and Departure Corridors for selected terminal airspace ^ # *

5.2.4.2 Determine Horizontal Extent of Smoke from Forecast Location of Obscurations Aloft ^ #

5.2.4.3 Determine Vertical Extent (FL) of Smoke from Forecast Locations Obscurations Aloft ^ #

5.2.4.4 Determine Horizontal Extent of Blowing Dust from Forecast Locations Obscurations Aloft ^ #

5.2.4.5 Determine Vertical Extent (FL) of Blowing Dust from Forecast Locations Obscurations Aloft ^ #

COORDINATION VERSION

5.2.4.6 Determine Horizontal Extent of Blowing Sand from Forecast Locations Obscurations Aloft ^ #

5.2.4.7 Determine Vertical Extent (FL) of Blowing Sand from Forecast Locations Obscurations Aloft ^ #

5.2.4.8 Determine Horizontal Extent of Fog from Forecast Locations Obscurations Aloft ^ #

5.2.4.9 Determine Vertical Extent (FL) of Fog from Forecast Locations Obscurations Aloft ^ #

5.2.4.10 Determine Beginning Time of Obscurations Aloft from Forecast Locations Obscurations Aloft

5.2.4.11 Determine Ending Time of Obscurations Aloft Forecast Locations Obscurations Aloft

5.2.4.12 Forecast Type of Obstruction Aloft

5.2.5 Forecast Location of Precipitation Aloft ^ #

5.2.5.1 Determine Horizontal Extent of Liquid Precipitation from forecast location of precipitation aloft ^ #

5.2.5.2 Determine Vertical Extent (FL) of Liquid Precipitation from forecast location of precipitation aloft ^ #

5.2.5.3 Forecast Rain Calculate liquid precipitation Density from forecast location of precipitation aloft (WP) ~~(moderate or greater)~~ ^ # *

5.2.5.3.1 ~~Forecast Horizontal Extent of Drizzle (WP)~~ [not consistent] ^ #

5.2.5.4 Forecast Location of Solid Precipitation Aloft ^ # *

5.2.5.4.1 Determine Horizontal Extent of Hail from forecast location of solid precipitation aloft Snow ^ # *

5.2.5.4.2 Determine Vertical Extent (FL) of Hail from forecast location of solid precipitation aloft ^ # *

5.2.5.4.3 Forecast Snow Density ~~(Moderate or Greater)~~ (WP) ^ #

5.2.5.4.4 Forecast Ice Pellets Density ~~(Moderate or Greater)~~ (WP) ^ # *

~~5.2.5.5 Forecast Location of Freezing Precipitation (WP) ^ # * ~~

~~5.2.5.5.1 Determine Freezing Level Aloft from forecast of temperatures ^ # * ~~

~~5.2.5.5.2 Determine Horizontal Extent of Freezing Precipitation from forecast location of freezing precipitation aloft ^ # * ~~

5.2.5.6 Calculate duration of precipitation aloft from forecast location of precipitation aloft

5.2.5.6.1 Determine Beginning Time of Precipitation Aloft from forecast location of precipitation aloft

5.2.5.6.2 Determine Ending Time of Precipitation Aloft from forecast location of precipitation aloft

5.2.6 Forecast Location of Turbulence (WP)

5.2.6.1 Determine 3-D Extent of Turbulence from Forecast Location of Turbulence ~~of Convective Induced Turbulence (CIT) Within 30nm of TS~~ ^ # * ~

~~5.2.6.1.1~~ Determine Horizontal Extent of ~~Convective Induced~~ Turbulence ~~(CIT) Within 30nm of TS~~

COORDINATION VERSION

~~5.2.6.1.2~~ Determine Vertical Extent of ~~Convective Induced~~ Turbulence ~~(CIT)~~

5.2.6.2 Forecast Intensity of Turbulence ~~CIT~~ (WP) ^ # * ~

~~5.2.6.2.1 Determine 3-D Location(s) of Clear Air Turbulence (CAT) ^ # * ~~

~~5.2.6.2.2 Determine Horizontal Extent of Clear Air Turbulence (CAT) ^ # * ~~

~~5.2.6.2.3 Determine Vertical Extent of Clear Air Turbulence (CAT) ^ # * ~~

5.2.6.3 ~~Forecast 3-D Locations(s) of CAT Due to Topography (e.g., Mountain Waves, Rotors) (WP)~~ ^ # * ~

5.2.6.4 Determine Type of Turbulence (CIT or CAT) (WP) ^ # * ~

5.2.6.5 Calculate duration of turbulence aloft from forecast location of turbulence

5.2.6.5.1 Determine Beginning Time of Turbulence Aloft from forecast location of turbulence

5.2.6.5.2 Determine Ending Time of Turbulence Aloft from forecast location of turbulence

5.2.7 Forecast Space Weather (e.g., Solar Flares, Coronal Mass Ejections)

5.2.7.1 Forecast Solar Radiation Activity Affecting Aviation for 12, 24, 36, and 48 hours in Advance ^ # *

5.2.7.2 Forecast Regions (e.g., Space, Polar, High-Latitude, and Mid-Latitude) Susceptible to Moderate Energy Levels (> 10MeV) of Solar Radiation for 12, 24, 36 and 48 Hours in Advance ^ # *

5.2.7.3 Forecast Regions (e.g., Space, Polar, High-Latitude, and Mid-Latitude) Susceptible to High Energy Levels (> 100 MeV) of Solar Radiation for 12, 24, 36 and 48 Hours in Advance ^ # *

5.2.7.4 Forecast Where Solar Activity Significantly Degrades HF Comms. (WP) 12, 24, and 36 Hours in Advance ^ # *

5.2.7.5 Forecast Where Solar Activity Will Significantly Degrade Navigation Systems (WP) 12, 24, and 36 Hours in Advance ^ # * ~

5.2.7.6 Forecast Intensity of Solar Radiation (WP) 12, 24, and 36 Hours in Advance ^ # * ~

5.2.7.7 Forecast Period of Solar Radiation Maximum Exposure (WP) 12, 24, and 36 hours in Advance ^ # ~

5.2.7.8 Forecast Duration of Solar Radiation (WP) 12, 24, and 36 hours in Advance ^ # ~

5.2.8 Forecast Other Weather (Aloft) ^ # *

5.2.8.1 Determine Volcanic Ash Dispersion from forecast location of volcanic ash ^ # * ~

5.2.8.2 Calculate Movement of Volcanic Ash Cloud from forecast location of volcanic ash and forecast Wind Speed and Direction ^ # * ~

5.2.8.3 Determine 3-D Extent of Volcanic Ash Cloud from forecast location of volcanic ash ^ # * ~

5.2.8.4 **Forecast Dew Point Temperature Aloft** (WP)

5.2.8.5 **Forecast Temperature Aloft (WP)**

5.2.8.6 **Forecast Pressure Aloft (WP)**

COORDINATION VERSION

6 Store/Archive Weather Information

6.1 Store User Weather Information

6.2 Store Weather Information in 4-D Wx SAS Store Weather Information in 4-D Wx Cube

6.3 Store Weather Information Short Term (< 48 hours)

6.4 Store Weather Information Long Term (> 48 hours to 15 days)

6.5 Archive Weather Information Indefinitely (>15 days)

6.6 Store Weather Information in 4-D Wx Cube

7 Provide Climatology

7.1 Provide Monthly Climatology

7.2 Provide Tropical Cyclone Climatology

7.3 Provide 13 Year Climatologies

7.4 Provide 30 Year Climatologies

7.5 Provide Surface Observation Climatological Summaries

7.6 Provide Wind Stratified Conditional Climatology

7.7 Provide Thunderstorm Climatology

8 Display Forecasts

8.1 Display Weather Information for Meteorologist

8.2 Display Weather Information for User

9 Manage 4-D Wx SAS

9.1 Manage Access to 4-D Wx SAS

9.2 Protect Proprietary Weather Information

9.3 Accept Request for Weather Information

9.4 Accept Weather Information Updates

9.5 Manage Weather Information Publication

9.6 Manage Weather Information Subscriptions

9.7 Manage Weather Information Subscription Queues

9.8 Retrieve Requested Weather Information

9.9 Prepare Weather Information for Communication

9.10 Manage Business Rules

9.11 Prioritize Subscription Queues

9.12 Maintain Meta Data Tag Information

9.13 Update Meta Data Tag Information

COORDINATION VERSION

9.14 Maintain Availability
9.15 Maintain Reliability Meta Data Tagging Information

10 **Manage Weather Data**
10.1 Assess Weather Information Production
10.2 Perform Weather Research and Development
10.3 Plan Weather Information Production Information Changes
10.4 Implement Weather Information Production Information Changes
10.5 Produce Weather Information
10.6 Manage Weather Infrastructure

11 **Provide Weather Enterprise Decision Support Services**
11.1 Calculate Value of Meteorological Parameters
11.1.1 Calculate Vertical Extent of Meteorological Parameters
11.1.2 Calculate Horizontal Extent of Meteorological Parameters
11.1.3 Calculate rate of fall of Meteorological Parameters
11.1.4 Calculate intensity of Meteorological Parameters
11.1.5 Calculate Beginning time of Meteorological Parameters
11.1.6 Calculate Ending time of Meteorological Parameters
11.1.7 Calculate Water Equivalent of Meteorological Parameters
11.1.8 Calculate Pressure Parameters
11.1.9 Calculate Duration of Meteorological Parameters
11.1.10 Calculate Average of Values of Meteorological Parameters
11.2 Sum Values of Meteorological Parameters
11.3 Develop Meteorological Climatologies
11.4 Extract Weather Information by Volume of Airspace
11.4.1 Extract Weather Information along Flight Path
11.4.2 Extract Weather Information for Airspace Volume from Surface to Top of NAS
11.4.3 Extract Weather Information by Flight Levels
11.4.4 Extract Weather Information by ICAO identifier
11.4.5 Extract Weather Information by Terminal Area
11.4.6 Extract Weather Information by Time Period
11.4.7 Extract Weather Information by Vertical Cross-section
11.4.8 Extract Weather Information above a Specified Threshold
11.4.9 Extract Weather Information by Geographical Area.

COORDINATION VERSION

11.5 Format Weather Information into ICAO-Required Textual Product

11.6 Construct Graphics with Digital Weather Information Extracted from 4-D Wx SAS/Cube

11.7 Convert Meteorological Parameters between Measurement systems

11.7.1 Convert Height between Mean Sea Level and Above Ground Level

11.7.2 Convert Temperature between Celsius and Fahrenheit

11.7.3 Convert Winds between True North and Magnetic

11.7.4 Convert between Map Projections

11.8 Analyze Meteorological Parameters

11.9 Determine Value of Meteorological Parameters

User functions that require weather support but that are not performed as a weather function, per se, are listed below. In the NextGen era, a decision support tool (DST) would perform this function (for the User) to assess the operational impact after ingesting the weather data/information.

UDST1 Determine Runway Braking Conditions Due to Rain

UDST2 Determine Runway Braking Conditions Due to Snow ^ # * ~ %

UDST3 Determine Runway Braking Conditions to Surface Icing ^ # * %

UDST4 Observe Volcanic Eruptions (Svc Standard Level A) ^

UDST5 Forecast Impact of Thunderstorms on ARTCC Sector Capacity (WP) # *

UDST6 Forecast Impact of Thunderstorm on Route Capacity (WP) ^ # *

UDST7 Forecast Proximity of Heavy Precipitation (> 1.5"/hour) to Airport/Spaceport (WP) ^ # * ~

UDST8 Determine When Hurricane/Typhoon-Strength Winds Will Impact FAA-Controlled airspace ^ # * ~

UDST9 Determine When Hurricane/Typhoon-Related Precipitation Will Impact FAA-Controlled Airspace ^ # * ~

~~UDST.10 Calculate Snowfall Intensity~~ [Deleted as Duplicate] ~~^ # * %~~

~~UDST.11 Determine Surface Icing Accretion Accumulation for 1, 3, and 6 hours [Deleted as Duplicate]^ # *~~

UDST12 Forecast Weather Traffic Impacts (e.g., thunderstorm, obscurations) to Arrival/Departure Corridors at Super-density Airports Out UDST to 4 hours ^ # * ~

UDST13 Determine Snow Increasing Rapidly (>1 inch per hour) at Super-density Airports ^ # %

UDST14 Forecast Impacts at Arrival/Departure "Corner Posts" Out to 50nm at Super-density Airports 4-6 Hours in Advance # *

F1.1.12.15 Determine impact of forecast icing on aircraft by type

F1.1.12.16 Determine impact of forecast turbulence on aircraft by type

COORDINATION VERSION

Appendix C – 4-D Wx SAS Functional and Performance Criteria Tables.

Table N-1 Observational Performance Requirements

Table N-1a

Location Above Surface		Super-Density Terminal Airspace		En Route Airspace		Global Airspace		Designated En Route Terminal Airspace		Designated Global Terminal Airspace	
		Convective	All Other*	Convective	All Other*	Convective	All Other*	Convective	All Other*	Convective	All Other*
Horizontal Resolution	At reference tolerance bias	1/2 km	1/2 km	1 km	4 km	10 km	10 km	1 km	4 km	10 km	10 km
Accuracy ** (Horiz Res)		1/4 km	1/4 km	1/2 km	2 km	5 km	5 km	1/2 km	2 km	1/2 km	5 km
Vertical Resolution - At reference tolerance bias	5,000 ft to Top of Terminal Airspace	500 ft	500 ft	500 ft	500 ft	500 ft	500 ft	500 ft	500 ft	500 ft	500 ft
	Surface to 5,000 ft	100 ft	100 ft					100 ft	100 ft	100 ft	100 ft
Accuracy ** (Vert Res)	5,000 ft to Top of Terminal Airspace	250 ft	250 ft	250 ft	250 ft	250 ft	250 ft	250 ft	250 ft	250 ft	250 ft
	Surface to 5,000 ft	50 ft	50 ft					50 ft	50 ft	50 ft	50 ft
Update Period ***	Nominal time interval	1 min	5 min	2 min	5 min	10 min	20 min	1 min	5 min	2 min	20 min

Table N-1b

Location at Surface	Surface of Selected Terminal Airspace		En Route Airspace ****		Global Airspace	
	Convective	All Other*	Convective	All Other*	Convective	All Other*
Horizontal Resolution	1/2 km	1/2 km	1 km	4 km	4 km	10 km
Accuracy ** (Horiz Res)	1/4 km	1/4 km	1/2 km	2 km	2 km	5 km
Update Period ***	1 min	1 min	2 min	5 min	10 min	15 min

N-1 NOTES:

* "All Other" contains weather that is "other" than Convection or Clouds (excludes Space Weather)
** The accuracy values are plus or minus (+) the number specified in the table(s)
*** Update Period is less than or equal to the value listed
**** Smaller U.S. airports are included in En Route Airspace.

Table N-2 Forecast Performance Criteria

Table N-2a Increment	Super-Density Terminal Airspace		Designated En Route Terminal Airspace and En Route Airspace		Designated Global Terminal Airspace and Global Airspace
FORECAST	Convection	Other Wx	Convection	Other Wx	
0 to 15 mins	1 min	15 min	15 min		
> 15 mins to 45 mins	5 min				
> 45 mins to 2 hours	10 min			1 hour	
> 2 hours to 4 hours	15 min		1 hour		
> 4 hours to 60 hours	1 hour	1 hour			
> 60 hours to 14 days	3 hours				6 hours
> 14 days to 90 days	12 hours				

Table N-2b Production Timelines (Temporal Resolution)	Super-Density Terminal Airspace		Designated En Route Terminal Airspace and				Designated Global Terminal Airspace and Global	
			Convection		Other Wx			
FORECAST	Production Rate	Latency	Production Rate	Latency	Production Rate	Latency	Production Rate	Latency
0 to 2 hours	5 min	2.5 min	10 min	5 min	30 min	15 min	3 Hours	90 min
> 2 hours to 4 hours	10 min	5 min	30 min	15 min				
> 4 hours to 10 hours	30 min	15 min	60 min	30 min	60 min	30 min		
> 10 hours to 24 hours	1 hour	30 min	3 hours	90 min	3 hours	90 min		
> 24 hours to 5 days	3 hours	90 min			6 hours	3 hours	6 hours	3 hours
> 5 days to 14 days	6 hours	3 hours	6 hours	3 hours				
> 14 days to 90 days	Monthly	One Day	Monthly	One Day	Monthly	One Day	Monthly	One Day

Table N-2c Horizontal Resolution	Super-Density Terminal Airspace	Designated En Route Terminal Airspace and En Route Airspace	Designated Global Terminal Airspace and Global Airspace
Convection	1/2 km	1 km	10 km
All Other		4 km	

Table N-2d Vertical Resolution	Super-Density Terminal Airspace	Designated En Route Terminal Airspace and En Route Airspace	Designated Global Terminal Airspace and Global Airspace
Top of NAS to 5,000 ft	500 ft	500 ft	
4,900 ft to Surface	100 ft		

Table N-2e Forecast Accuracy - Begin / End Times	Application	Super- Density Terminal Airspace		Designated En Route Terminal Airspace and En Route Airspace		Designated Global Terminal Airspace and Global Airspace
		Convection	Other Wx	Convection	Other Wx	
0 to 15 mins	ATM	± 2.5 min	± 5 min	± 15 min		
> 15 mins to 45 mins						
> 45 mins to 2 hours						
> 2 hours to 4 hours		± 5 min				
> 4 hours to 10 hours		± 15 min	± 15 min			
> 10 hours to 24 hours	Next Day Plan	± 30 min				± 1 hour
> 24 hours to 60 hours	AOC Plan					
> 60 hours to 14 days	NAS Outlook	± 1 hour				± 3 hours
> 14 days to 90 days		± 12 Hours				

Table N-2f Forecast Accuracy - Bases / Tops	Super-Density Terminal Airspace	Designated En Route Terminal Airspace and En Route	Designated Global Terminal Airspace and Global Airspace
0 to 2 hours		250 ft	
5,000 ft - Top of NAS	250 ft		
Surface to 4,900 ft	50 ft		
> 2 hours to 4 hours			
5,000 ft - Top of NAS	250 ft		
Surface to 4,900 ft	50 ft		
> 4 hours to 10 hours		500 ft	
5,000 ft - Top of NAS	500 ft		
Surface to 4,900 ft	100 ft		
> 10 hours to 24 hours			
5,000 ft - Top of NAS	500 ft		
Surface to 4,900 ft	100 ft		
> 24 hours to 60 hours		1,000 ft	
5,000 ft - Top of NAS	1,000 ft		
Surface to 4,900 ft	150 ft		
> 60 hours to 14 days		1,500 ft	
5,000 ft - Top of NAS	1,500 ft		
Surface to 4,900 ft	250 ft		
> 14 days to 90 days (Surface to Top of NAS)	3,000 ft		

Table N-2g Forecast Accuracy - Location (Lat/Long)	Super-Density Terminal Airspace	Designated En Route Terminal Airspace and En Route Airspace		Designated Global Terminal Airspace and Global Airspace
		Convection	Other Wx	
0 to 15 mins	1/4 km	1/2 km	2 km	5 km
> 15 mins to 45 mins				
> 45 mins to 2 hours				
> 2 hours to 4 hours		1 km		
> 4 hours to 10 hours	1/2 km	2 km	2 km	
> 10 hours to 24 hours				
> 24 hours to 60 hours	1 km			
> 60 hours to 14 days	2 km	4 km		8 km
> 14 days to 90 days	12 km			

Table N-2h Forecast Skill Verification	Super-Density Terminal Airspace	Designated En Route Terminal Airspace and En Route Airspace	Designated Global Terminal Airspace and Global Airspace
0 to 15 mins	95%	92%	88%
> 15 mins to 45 mins			
> 45 mins to 2 hours	92%		
> 2 hours to 4 hours	90%	88%	
> 4 hours to 10 hours	88%	85%	82%
> 10 hours to 24 hours	85%	82%	80%
> 24 hours to 60 hours	75%	75%	75%
> 60 hours to 14 days	60%	60%	60%
> 14 days to 90 days	55%		

Runway Visual Range (RVR) Forecast Horizontal	Runway Visual Range (RVR Forecast Horizontal Accuracy)				
	0 -149 feet	150-699 feet	700 - 1199 feet	1200 - 1799 feet	1800 - 2400 feet
0-15 min	± 45 feet	± 150 feet	± 200 feet	± 200 feet	± 225 feet
16-30 min	± 50 feet	± 175 feet	± 200 feet	± 225 feet	± 250 feet
31-45 min	± 60 feet	± 200 feet	± 225 feet	± 250 feet	± 275 feet
46-90 min	± 75 feet	± 225 feet	± 250 feet	±275 feet	± 300 feet

DRAFT VERSION

Appendix D – 4-D Wx SAS Performance Requirements for Observe Atmospheric and Space Conditions for Super Density Terminals Airspace.

The 4-D Wx SAS Performance Requirements are provided in a separate MS Excel file.

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Appendix E – Performance Requirements for Forecast Weather for Super Density Terminals Airspace.

The 4-D Wx SAS Performance Requirements are provided in a separate MS Excel file.

COORDINATION VERSION

Appendix F - NextGen 4-D Wx SAS Functional Probability Requirements.

In the tables below you will occasionally see reference to probability mass functions (PMF) and probability density functions (PDF).

> A Probability Mass Function (PMF) is used to forecast the probability of two or more discrete categories of an event. PMF categories typically describe events with a qualitative nature. For example, a PMF for describing obstruction to vision may provide a probability of each type of obstruction: haze, smoke, fog, mist, blowing snow, blowing spray, blowing dust, blowing sand, and none.

> A Probability Density Function (PDF) represents the probability of an event and its magnitude. In a PDF, magnitude values are not binned or segregated into categories, but are continuous. This allows DSTs using PDFs more flexibility in identifying the probability of events of magnitudes of interest to the user. For example, if the forecast magnitude of turbulence is binned into only five groups described as “light,” “moderate, “severe,” “extreme,” and “none,” a user could not further distinguish within “moderate” the precise Eddy Dissipation Rate (EDR) magnitude that triggers concern by airframe to customize the forecast to a specific user and their EDR tolerance. Forecast PDFs of turbulence by EDR allow each user can draw probability curves of any EDR value ranges of interest. Users do not have to rely on preselected ranges which may not suit his/her needs.

Reference is also made to specific requirements for elements “caused by free convection”. This is to indicate a special requirement (e.g., higher resolution) in a thunderstorm. It is worded this way because it is difficult to say whether a point in 3-D space is, or is not part of a thunderstorm.

Note: These 4-D Wx SAS functional requirements will be incorporated into Appendix B after the associated performance requirements are developed.

The 4-D Wx SAS Functional Probability Requirements are provided in a separate MS Excel file.

COORDINATION VERSION